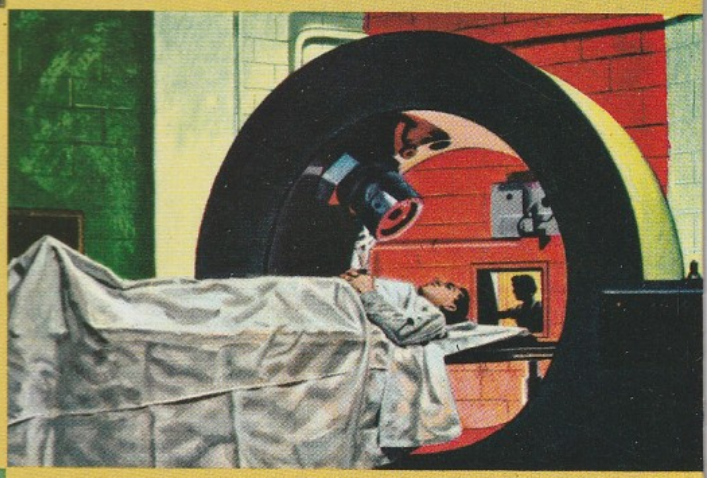
Science Service

MEDICAL DISCOVERIES

SCIENCE PROGRAM



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Prepared with the co-operation of
Science Service

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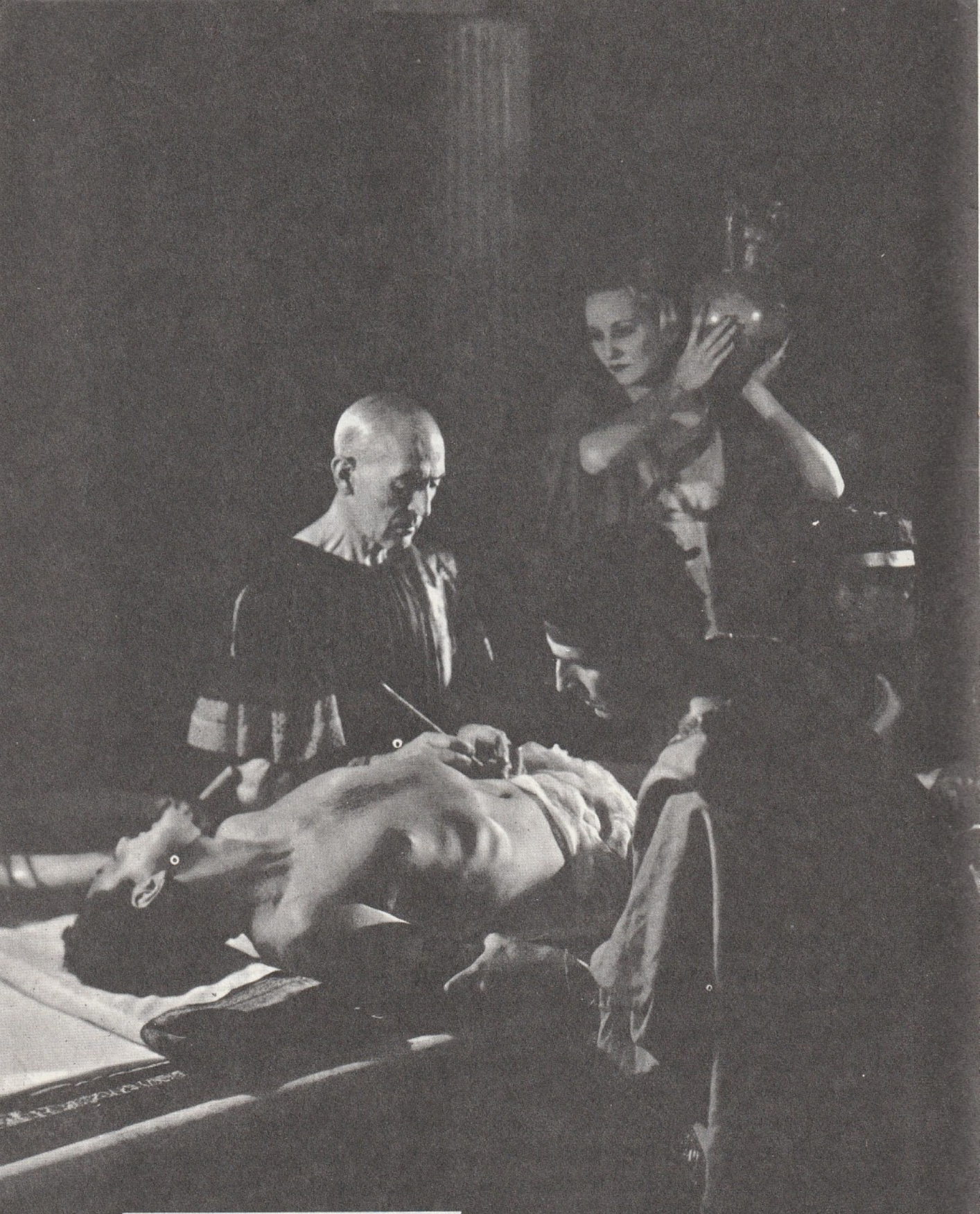
Miracles of Medicine

MODERN MIRACLES of medicine are made possible not by sudden startling discoveries of a single research worker, but by the steady, day-by-day experimental work of medical scientists all over the world. These scientists have trained and studied for many years, and above all have become familiar with the pioneering achievements of medical investigators who have preceded them.

Poets have written that "we stand on the shoulders of giants." This indicates that our successes are based on early inventors, discoverers and researchers who produced a foundation in science and technology. In medicine this is particularly true. Without the work of pioneers such as Jenner, Harvey, Lister and Pasteur we would not have medicine and surgery as we know it today. These and others are the "giants" on whose shoulders we stand. They took the first steps that were ultimately



Heliodorus was a noted Roman surgeon who practised during the reign of Trajan at the end of the first century A.D. This photo is from a film.

followed by modern scientists such as Jonas Salk and Selman Waksman.

In order to become better acquainted with the work of these great pioneers, and therefore to better understand modern medical progress, a review of great discoveries in medicine follows.

At the Beginning: Demons

IN ANCIENT TIMES disease was closely associated with superstition and belief in the supernatural. In many instances disease was thought to be a sign of demons or spirits invading the body. These were the times of primitive medicine and of the tribal "medicine man". Thus, the North American Indians, the Aztecs, the Incas and other early civilizations combined religion and medicine in one belief. This played a role in all tribal ceremonies, and the medicine man of each tribe used masks, charms, necklaces and symbols to drive off demons and spirits of disease. Extracts of plants and herbs were used frequently as potions for treating disease. Some of these plants actually contained useful products and are today the source of important drugs. Many narcotics and related drugs come from plants.

Of all the Indian civilizations, the Aztecs were the most advanced in medicine. They left written records of 3,000 plants used as remedies for hundreds of ailments. They practised surgery, set bones and made splints. In spite of their ignorance of the causes of disease, the Aztecs succeeded remarkably in primitive medicine, as we have learned from their historical manuscripts.

The original inhabitants of North, Central and South America had much in common with those of other parts of the world. In the lands of the Babylonians, the Egyptians and later the Hebrews, medicine was developed along primitive lines and the skill of ancient physicians was recorded.

Babylonians, for example, also considered demons as the source of diseases. They had a demon for liver disease, a demon for stomach disease—one for every disease they observed. Babylonian names for diseases were used through the ages, and many drugs used today still carry Babylonian names.

The Egyptians made great contributions to medicine. They first developed the specialized physician who treated only one type of disease. They had physicians for the eyes, the head, the teeth and other parts of the body. Here we can see the beginnings of today's high degree of specialization in medicine.

1. MEDICINE IN ANCIENT EGYPT

A white-robed physician in ancient Egypt treats a case of lockjaw. The patient is supported in a "brick chair", while the assistant at left holds a papyrus scroll describing the treatment.

Our knowledge of Egyptian medicine has been obtained from translations of the hieroglyphic writings of these ancient people. Many manuscripts have been found which were medical and surgical texts. These are believed to have been written around 1700 B.C. They contain knowledge of anatomy and physiology. They describe for the first time the brain, the heartbeat and various parts of the body. Also described are types of dislocations, ulcers, wounds and various disease conditions.

Egyptian practitioners had a great influence on the medicine of the cultures that followed. Hebrew medicine and Greek medicine, while contributing independently, also continued many of the medical practices that were originated by the Egyptians.

A craftsman decorating a column in ancient Egypt has been hurt. The surgeon, on the right, is binding up the wound with linen.

Mortars and other implements found in an ancient Greek pharmacy.

Moses, the legendary Hebrew leader, contributed the Mosaic Law which contained, among its precepts, a major advance in preventive medicine. This code laid down strict rules of sanitation in regard to food and drink, personal hygiene and the environment. Many of these rules are observed today and, when carried out effectively, prevent such diseases as typhoid, dysentery and tapeworm infestations.

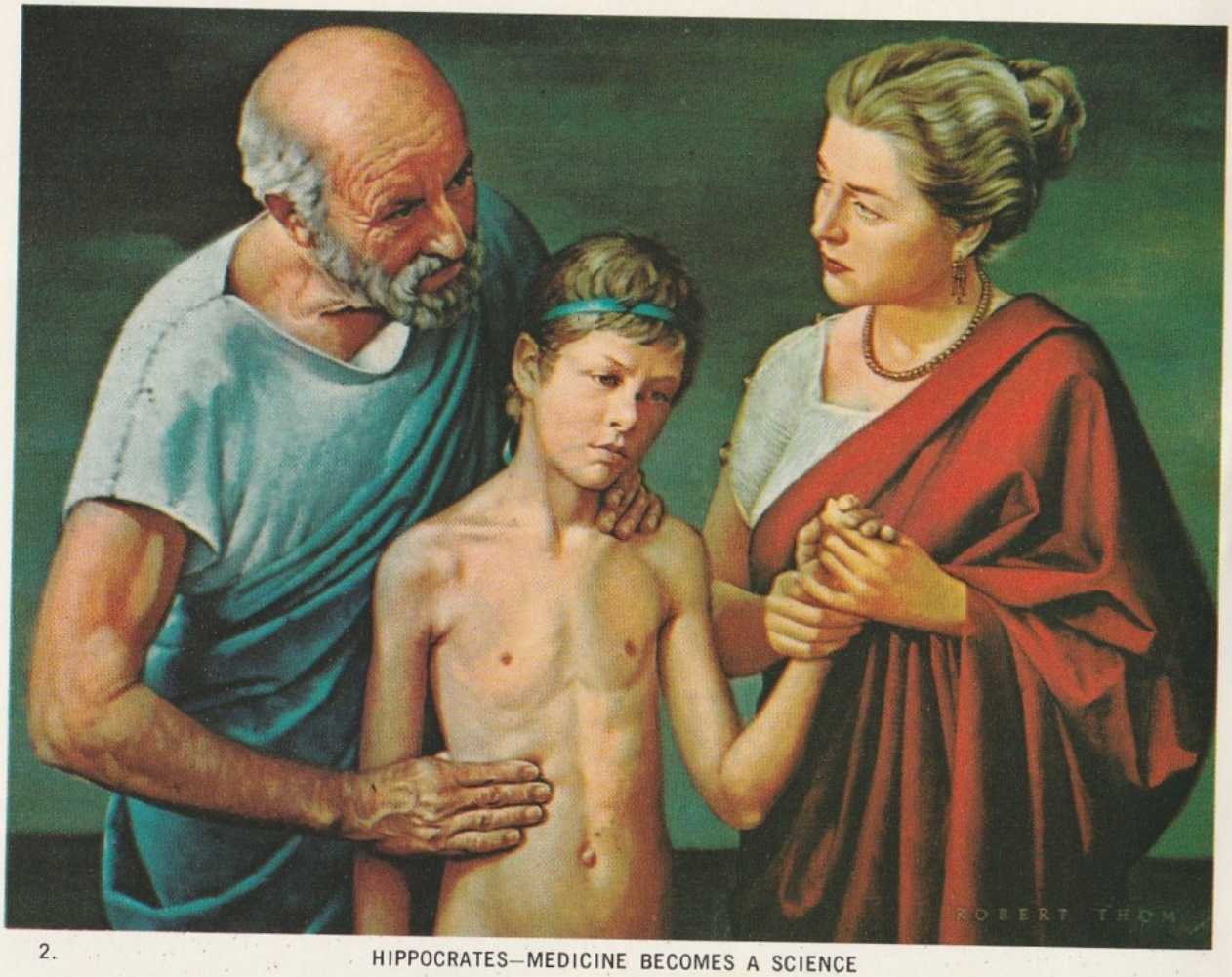
In addition to rules of cleanliness, the Hebrews introduced the circumcision rite among males, and described and treated such diseases as cancer, diphtheria and plague. Even mental diseases were described and commented upon. Thus, the Hebrews contributed markedly to the world's knowledge of medicine and especially to the field of sanitation, which has a great bearing on the transmission of infectious diseases.

Among other great cultures contributing to early medicine was the Chinese. China contributed many drugs, some very important in modern

medicine. In addition the Chinese also contributed to anatomy and physiology by studying various parts of the body and describing their functions. Nevertheless, the Chinese still associated medicine with religion, and it wasn't until the time of Hippocrates that medicine came into being as an independent science.

Hippocrates, the Father of Medicine

THE FAMOUS GREEK PHYSICIAN HIPPOCRATES was born on the Greek Island of Kos in 460 B.C. He was so skilled as a physician that students came from all over Greece to study and learn at his side. It is said that the only obligation Hippocrates imposed on his pupils was that



2. HIPPOCRATES—MEDICINE BECOMES A SCIENCE

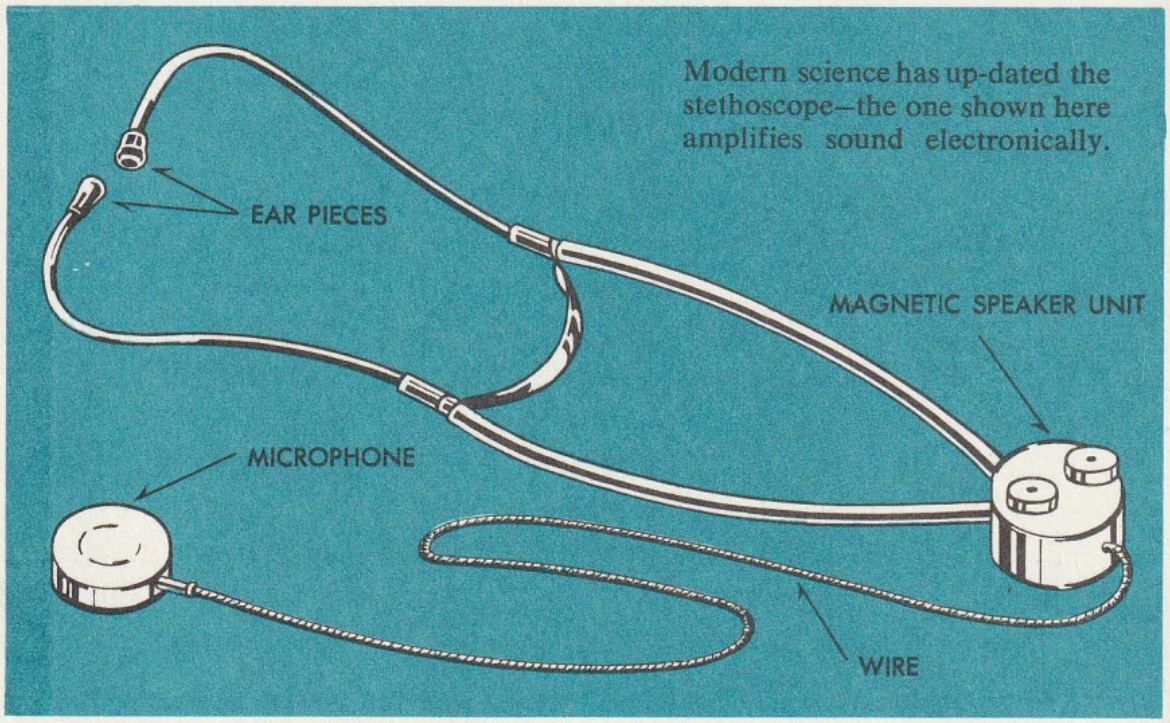
"Where there is love for mankind, there is love for the art of healing."

they swear to an oath in which a very high ethical code was set for them to live by. It is traditional today for medical graduates to recite a modified form of this oath when they receive their diplomas. The oath forbids unethical practices and serves as a guide for the moral and personal standards expected of those in the medical profession.

Medicine Emerges as a Science

HIPPOCRATES, AS WE HAVE NOTED, separated medicine from religion and also from philosophy. He actively disputed the idea of demons invading the body. He criticized "medicine men" and the idea of supernatural influence on disease. As the "father of medicine" he was the first to understand that the body has a natural tendency to rid itself of disease and introduced the idea that reactions such as fever and inflammation could be beneficial and were methods which the body used to fight disease.

One of the most direct and useful contributions of Hippocrates was his writings on the development of a method of prognosis. Prognosis is the judgment of what will be the duration, course and termination of a disease.

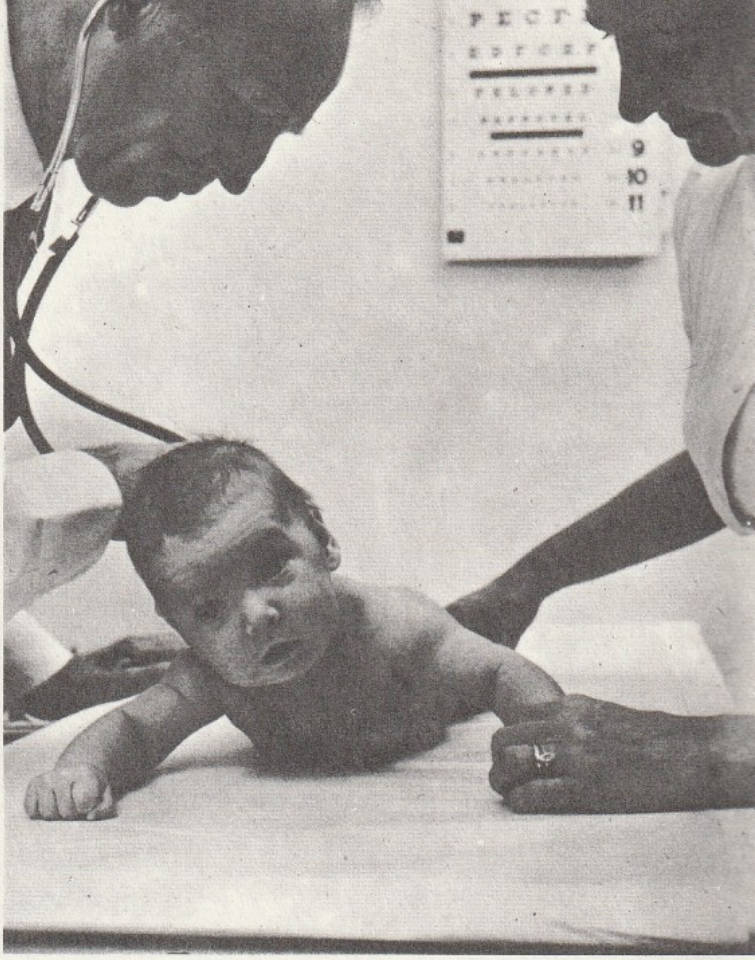


11. SUSRUTA—SURGEON OF OLD INDIA

Plastic surgery more than 2,000 years ago. The patient, drugged with wine, is being given an artificial ear lobe with flesh taken from his cheek.

By this manner the physician can best manage a cure and can tell the patient what to expect. Here, then, is one of the first signs of medicine's emergence as a science.

Another of the brilliant gifts of Hippocrates was his idea of physical diagnosis. Thus he recommended that all physicians carefully note the tone of their patients' skin, the appearance of the eyes, the bowel habits, the body stature, the temperature and similar physical factors. Hippocrates correctly understood that these outward conditions could indicate what was going on inside the body.



The doctor's most widely known instrument is the stethoscope. Here a doctor listens to the breathing of a healthy child.

This great physician wrote down descriptions of many of the diseases his patients had suffered. His observations were so accurate that his records of mumps, leprosy, fevers and tuberculosis would not be far out of place today in a modern medical-school lecture.

Along surgical lines, Hippocrates also left notable works. He described methods of treating fractures and dislocations, treatment of cranial injuries, spinal injuries and the need for cleansing wounds.

Hippocrates even considered the area of mental illnesses, or psychiatry. He felt that dreams were important and gave information on emotional problems of the patient. Hippocrates advised his pupils to study dreams and to try to relate to them the physical signs and symptoms of those who came for treatment.

Hippocrates' interests crossed all fields, and many precepts of modern medicine were introduced by his writings and teachings. His contributions were the first in a long list of great discoveries in medicine that have provided the basis for the longer and fuller life of man.

Although scientists have no doubt that Hippocrates was really a person, and a very great person, there are some who believe that the achievements attributed to him were not all the work of one individual, but of a

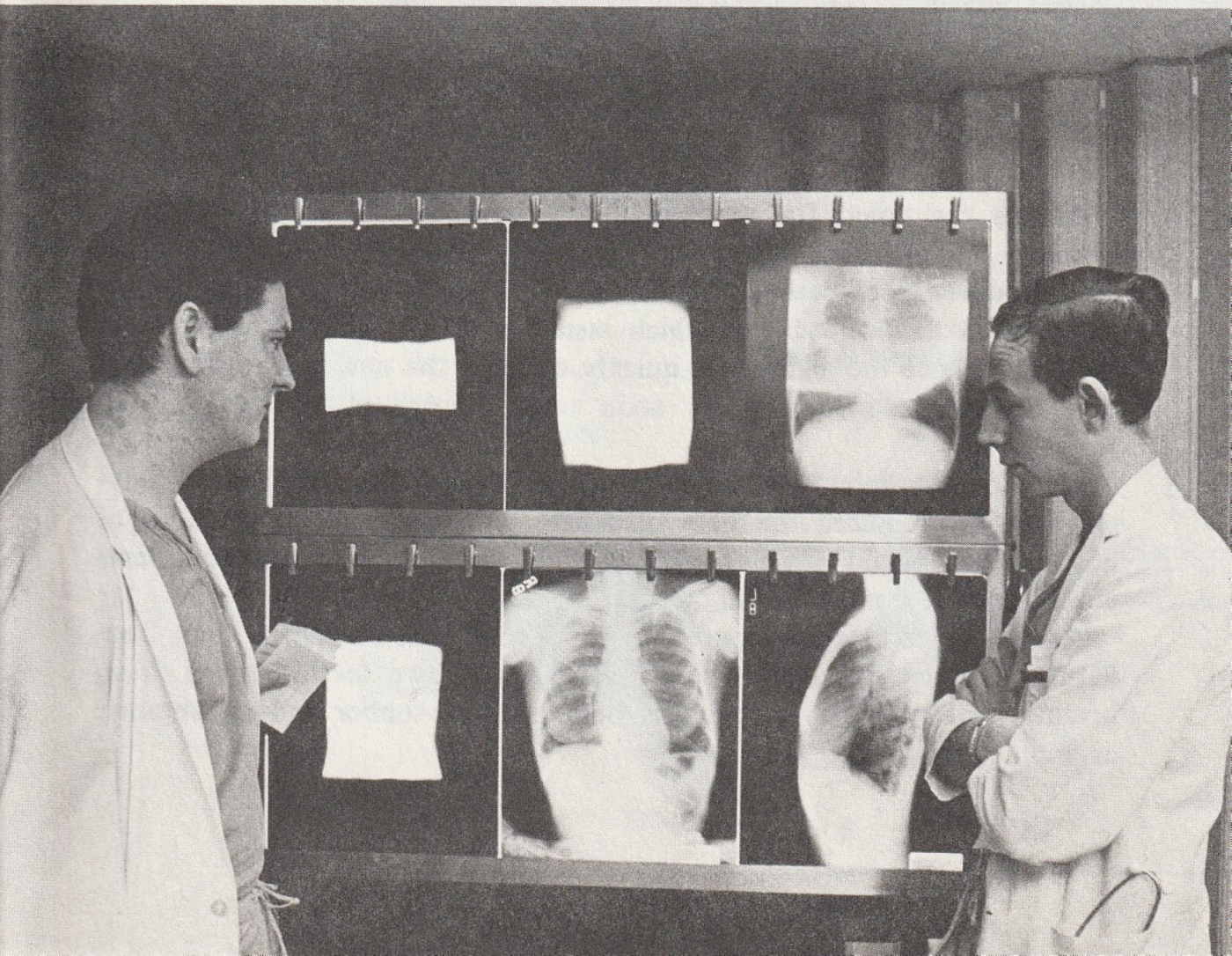
school bearing his name. Thus, some of the achievements may be due to his influence or inspiration, rather than to his own personal efforts.

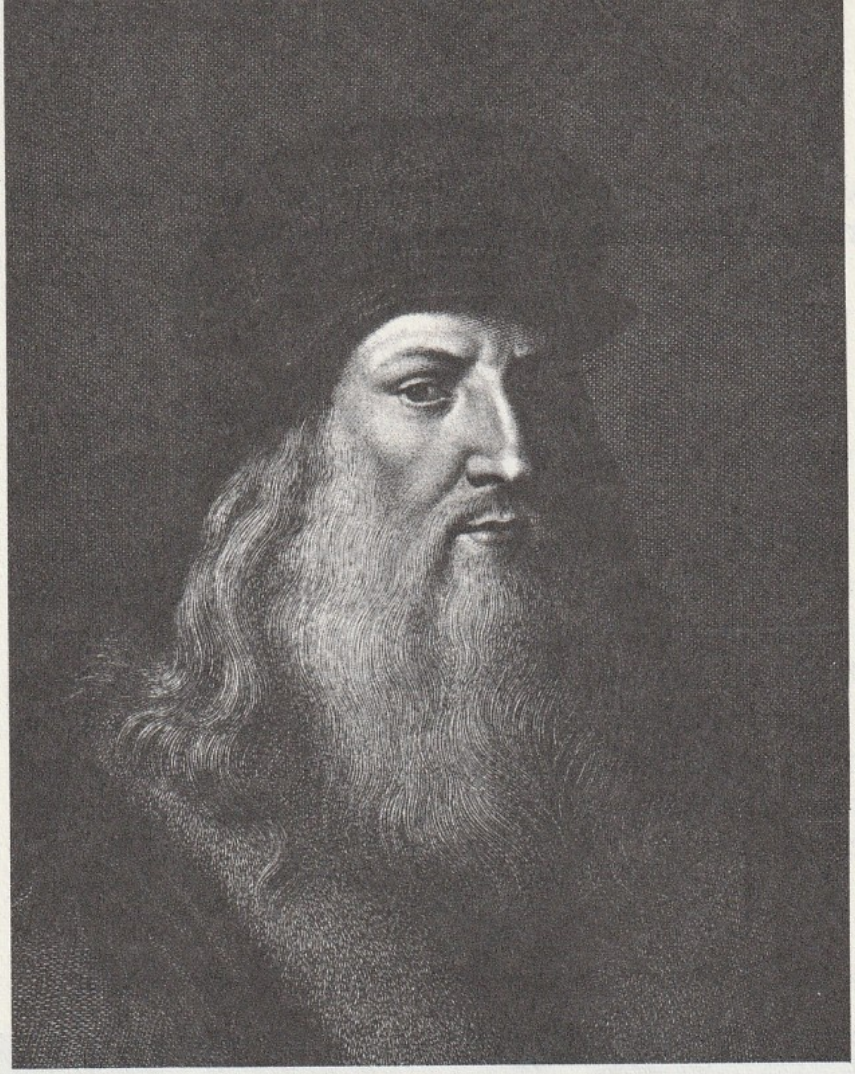
The Birth of Anatomy

THE SCIENCE OF THE STUDY OF THE HUMAN BODY is called *anatomy;* it serves as a foundation for other fields in medicine, including physiology and surgery.

Early workers in this field were men in the medical schools of Italy who in the fourteenth and fifteenth centuries made significant contributions. The difficulty in studying anatomy in those days arose from the fact that many groups of people opposed the dissection of the human body on religious grounds. Anatomists had to resort to the use of animal bodies, for the most part, to learn anatomy. The dog, the pig, the monkey and other domestic animals therefore were of immense importance to the first anatomical studies.

Modern equipment gives doctors information their predecessors had to do without.





LEONARDO DA VINCI

Among the noted Italian physicians of the day, Mondino de' Luzzi is known as the author of the first anatomy textbook, written about 1310. He introduced new methods by which to study anatomy and began a new direction in medical science which lasted until the sixteenth century in Italy. In France the anatomists quickly adopted the new science of Mondino and progress in anatomy soon went forward in all parts of the world.

Since photography was not available in those days, physicians studying anatomy required the help of artists to record the observations of human organs and structures. The physician who had artistic talents could hope to contribute markedly.

Among the artists who were active, none was more superb than Leonardo da Vinci. He was a true genius and is known for his career as an inventor, mathematician, engineer, botanist, philosopher and astronomer, as well as anatomist.

Leonardo was born in 1452. After studying painting he became a designer and conceived such mechanical devices as a turbine engine, a submarine, an army tank and a steamboat. These remarkable concepts were but a few of those he gave expression to during his lifetime.

The notebooks and manuscripts made in his study of anatomy were noted for their scientific accuracy. Leonardo made sketches of the skeleton, muscles, heart, lungs, brain and other organs—more than 750 of which have survived through history. It is believed that these drawings were part of a book on anatomy which Leonardo was preparing but never finished. Among the anatomical structures Leonardo described in accurate

3. VESALIUS AND THE ANATOMY OF MAN

Andreas Vesalius of Brussels was the first great teacher of anatomy from natural observations. He is depicted giving a demonstration at the University of Padua, where he taught.

detail were the eye and eyeball, the legs, the skull and the structure and function of the heart valves.

The influence of Leonardo on the course of anatomical progress would have been much greater had his notebooks and sketches been published during his lifetime. However, his manuscripts lay untouched for almost 300 years. It was not until 1796 that the original anatomical drawings of Leonardo da Vinci were published and made available to the public. As a result, the man who is said to have contributed most to the birth of anatomy as a science, and who became known as the "father of anatomy", was not Leonardo da Vinci but Andreas Vesalius, of Brussels, who was born sixty-two years after Leonardo.

Andreas Vesalius began his medical studies at the age of eighteen, in 1532. He spent several years studying under the masters of his day and displayed a marked interest in anatomy. As a youth he dissected mice, rats, dogs and cats and seemed fascinated by the structure of animals. For five years after receiving his doctor of medicine degree Vesalius lectured at Padua Medical School in Italy as professor of surgery and anatomy.

In 1543, at the age of twenty-nine, Vesalius completed his massive work *On the Fabric of the Human Body,* which was published in Switzerland. Authorities recognize this as a landmark in the history of medicine.

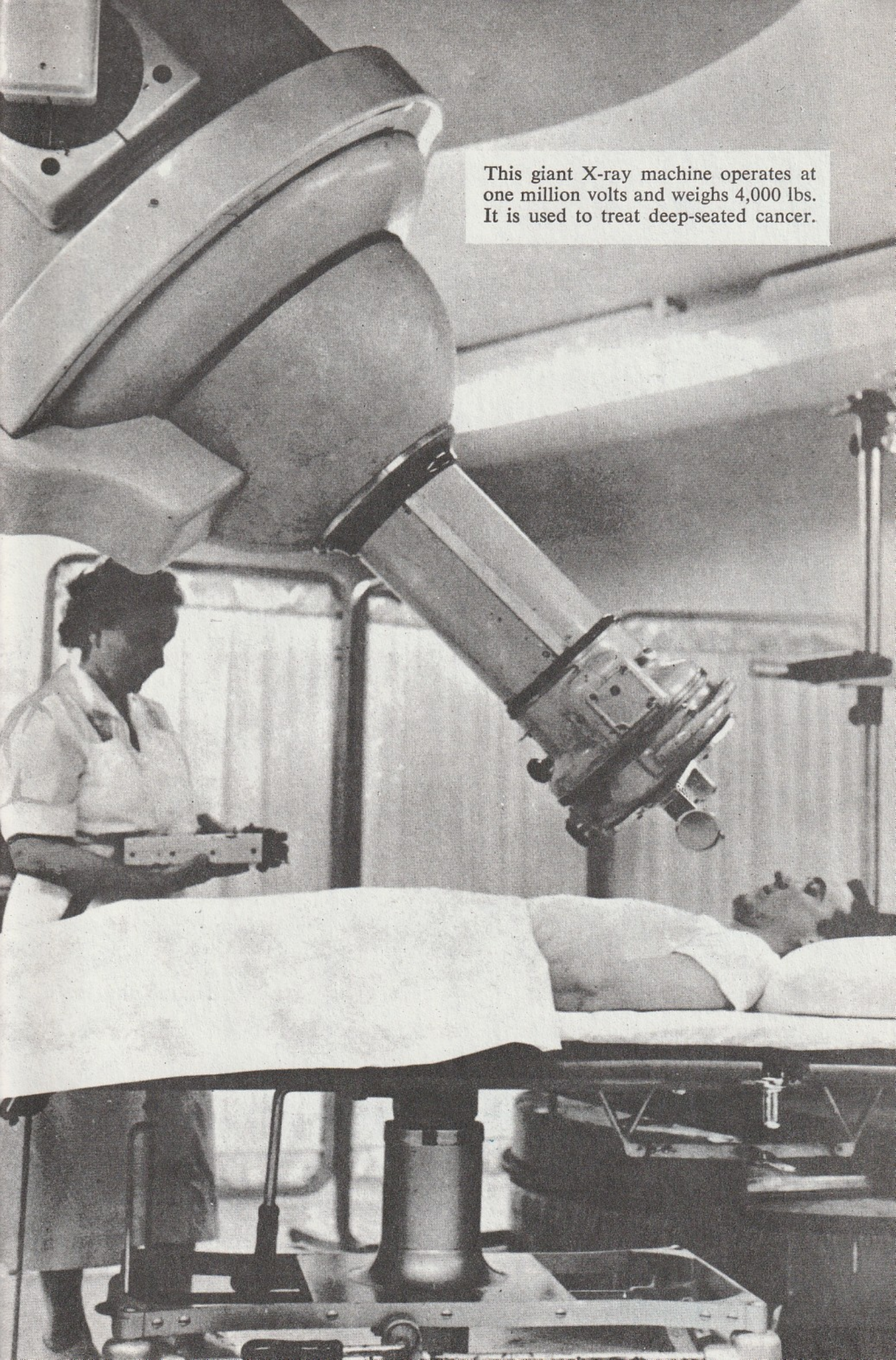
The "Fabrica", as this work was called, is divided into seven books. The first book is about the skeleton. Skulls are divided into long and broad categories. Bones are mentioned that had not been identified before. The vertebrae are described, as are the wrist bones, and the bones of the chest.

The second book describes the muscles of the body. Vesalius described the function of each muscle and how it was attached to the bones. The third book describes the circulatory system. It originally contained many errors that were eventually corrected by discoveries of Harvey some years later.

The fourth book concerns the nervous system. Vesalius proved that by cutting the nerves leading to the larynx (voice box), the voice was lost.

The fifth book describes the organs in the abdominal cavity—intestines, stomach, appendix, liver and so on. The sixth book describes the lungs and the heart. Finally, the seventh book describes the brain, the eyes and the pituitary gland—all quite accurately.

After completing this work Vesalius became the court physician to Emperor Charles V, to whom he dedicated his seven-volume treatise. Vesalius died in 1564. The impact of his masterful study of the human body is felt throughout the world of medicine to this day.



This giant X-ray machine operates at one million volts and weighs 4,000 lbs. It is used to treat deep-seated cancer.

MEDICINE HAS MANY SPECIAL FIELDS

Anesthesiologist A physician specializing in administration of anesthesia

Cardiologist One who specializes in diseases of the heart

Dermatologist A skin specialist

Gynecologist A physician specializing in diseases of women

Internist Physician who specializes in internal medicine and in the diagnosis of medical diseases

Neurologist A physician who specializes in diseases of the nervous system

Neuropsychiatrist One who treats both nervous and mental diseases

Neurosurgeon A surgeon who specializes in conditions affecting the nervous system

Obstetrician A physician who specializes in delivering babies

Ophthalmologist A physician who specializes in diseases of the eye

Optician One who makes eyeglasses, or who refracts eyes to note the necessary type of eyeglasses that should be worn

Optometrist One who measures or refracts eyes to note the need for eyeglasses

Orthopedist A physician who specializes in diseases of the bones, joints, muscles, tendons, etc.

Pathologist One who specializes in the study of the exact nature of disease by examination of tissues grossly and microscopically

Pediatrician A physician who treats diseases in children

Pharmacist A druggist or apothecary

Plastic surgeon A surgeon who is devoted to altering the shape of parts, or to the restoration of lost tissue

Podiatrist A specialist, not a physician, in conditions affecting the feet

Psychiatrist A physician who specializes in disorders of the mind

Psychologist A specialist, not necessarily a physician, who studies the function of the mind

Radiologist A physician who specializes in the use of X rays and other radioactive substances, both diagnostically and for treatment purposes

Urologist A physician who specializes in diseases of the urogenital system

4. HARVEY AND THE CIRCULATION OF BLOOD

William Harvey points to a vein while demonstrating his new theory.

Harvey: Circulation of the Blood

IN THE FIFTEENTH AND SIXTEENTH CENTURIES, the University of Padua in Italy was the world's mecca for education of physicians. William Harvey, born in England, entered the University of Padua in 1598 after completing his classical undergraduate studies at Cambridge. He received his medical degree in 1602 and returned to London to practise. Harvey was soon elected to the Royal College of Physicians, a learned and honorary group of medical workers.

At this time Harvey became interested in the function of the heart and the circulation of the blood. Although a few earlier investigators, such as Hieronymus Fabricius, one of the successors to Vesalius at Padua, had

described the heart and its valves, there was no complete explanation of the circulation of the blood.

Harvey proceeded to investigate this problem. He began his observations by examining the blood circulation systems of almost a hundred different kinds of animals.

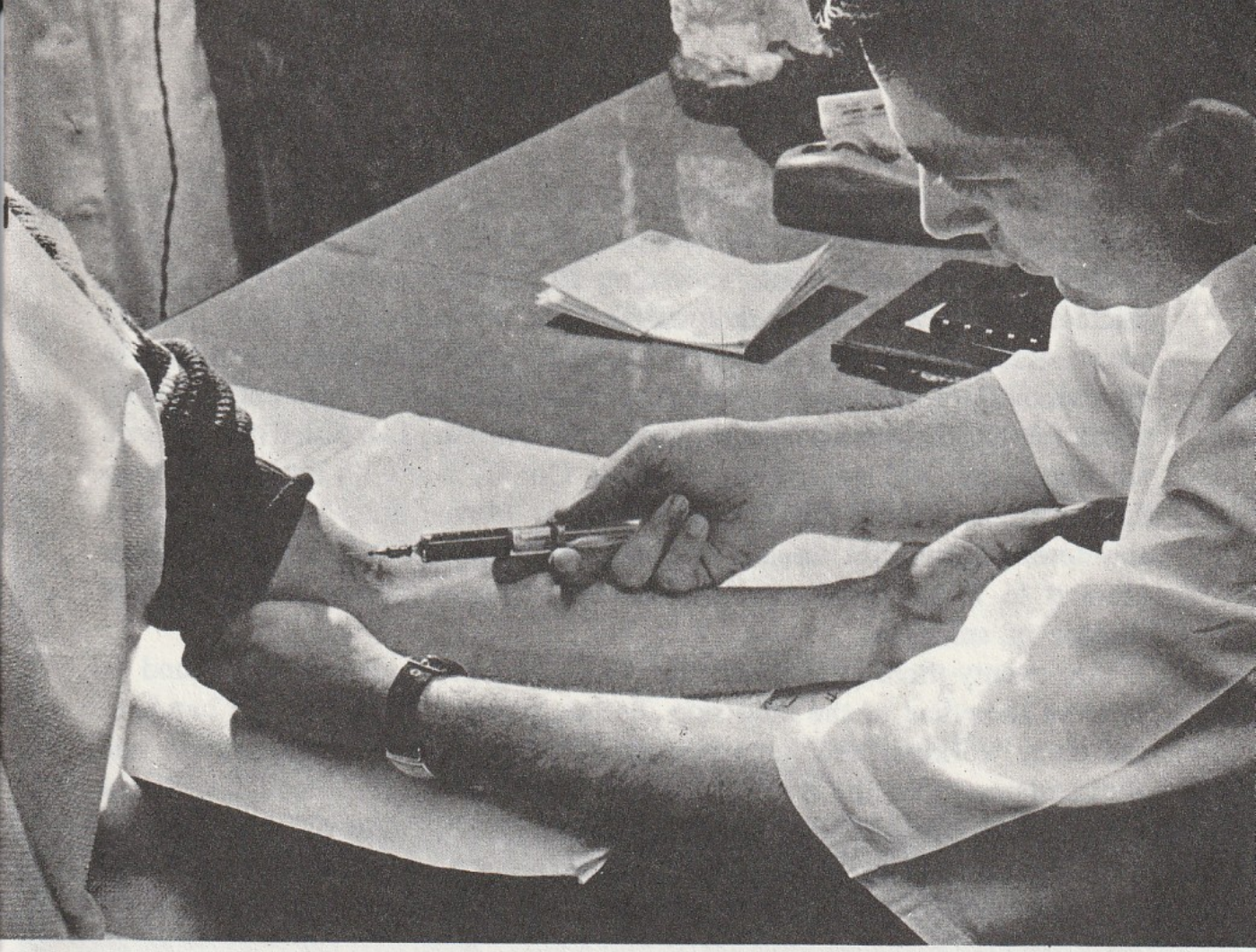
Harvey worked painstakingly on his research, examining and dissecting animals for nine years, each year accumulating more and more evidence on how the blood is circulated. He reported his results to the Royal College of Physicians, and finally in 1628 published his views, as determined by experiments, in a Latin treatise which was later translated as *Essay on the Motion of the Heart and the Blood.* On the basis of this description it became clear that Harvey had indeed made a remarkable contribution to the understanding of the circulatory system.

Harvey observed that when the heart contracted, it acted as a muscle and pumped blood into the arteries, each beat being felt in the pulse. In his further study of the heart he described how the valves opened and closed, preventing the backward flow of blood. Harvey reasoned that blood could flow in only one direction and must flow continuously. He estimated that each side of the heart pumped two ounces of blood at each beat, and beating seventy-two times a minute pumped nine pounds of blood through the circulatory system. He also reasoned that the same blood returned to the heart and was pumped around over and over again. He saw that the blood was forced into the arteries, then sent out to the body and to the lungs, then impelled in a circle to return to the heart via the veins.

William Harvey's writings included thirty or more studies in anatomical investigations. It is not possible to overestimate the great contributions of Harvey. By adding the study of function to the study of structure, he gave impetus to the new science of *physiology,* a medical specialty that describes not only what a body structure *is* but what it *does.* This was the birth of clinical medicine.

Questions About the Heart

As Harvey's work on circulation became known around the world, new questions arose. Since the heart pumped blood over and over, why didn't it wear out? Where did the energy come from to do all this work? What defects would the heart, arteries and veins undergo that might interfere with life? The answers to some of these questions are



A hypodermic syringe is used to extract a sample of blood.

still unknown. Nevertheless, we all know of the research on heart and blood disease that has been going on since Harvey's time. The physiologist has been studying blood components, clotting of bood, blood flow and blood vessel deficiency ever since the importance of this area was demonstrated by Harvey.

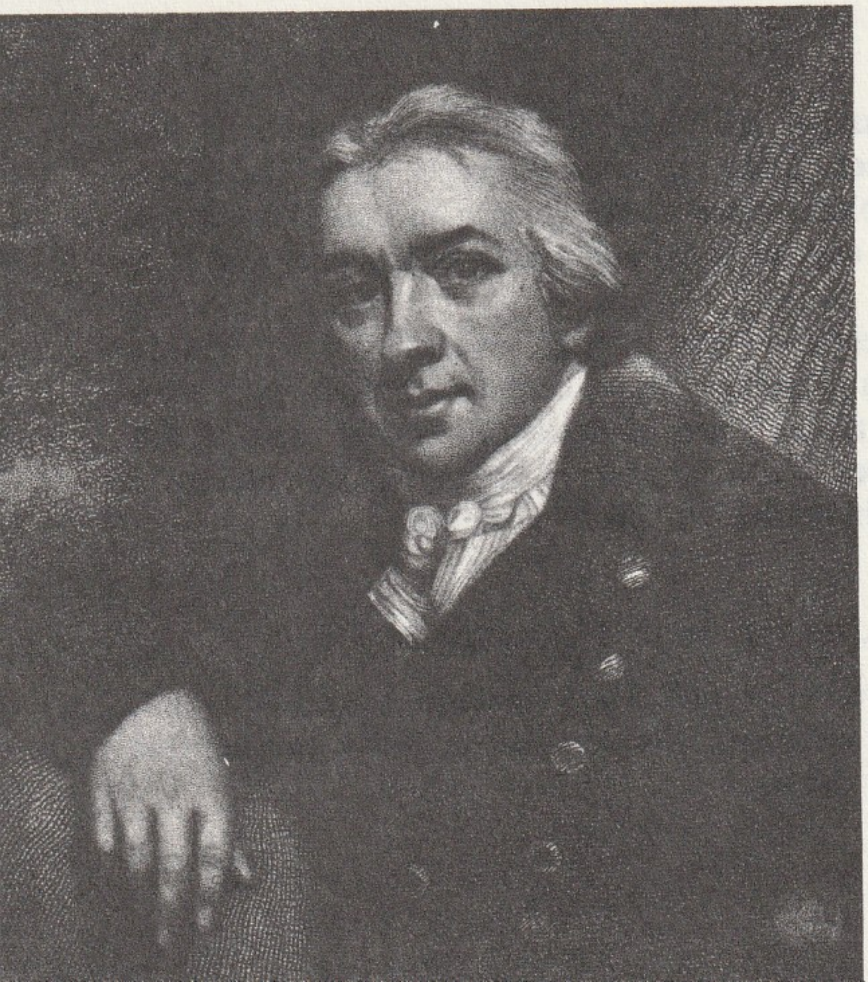
Problems such as hardening of the arteries, congenital heart defects and heart attacks have been plaguing man for centuries, but Harvey's work gave insight and direction to the paths of investigation that must be followed in the search of cures. Thus, circulatory physiology has become a major research field for physicians and other scientists.

Edward Jenner and Vaccination

EDWARD JENNER WAS ONE OF THE FIRST medical scientists to unravel the mysteries of infectious disease—that is, those diseases that are caused by bacteria and viruses.

Jenner had observed, during his practice as a country physician, that dairymen and milkmaids never contracted the dread disease called smallpox. He soon learned that, according to country legend, the people in contact with cows in their daily work were immune to smallpox. Jenner was fascinated by the story, and in his country medical practice in Gloucestershire, England, he began to observe systematically and patiently those people who worked with cows and who were exposed to cases of smallpox—but did not get the disease. On the basis of his observations Jenner found that milkmaids and dairy workers often contracted from the cows a very mild disease known as cowpox. Having had this disease seemed to make these people resistant to the severe and usually fatal disease of smallpox.

For twenty-three years, between 1773 and 1796, Jenner continued to observe the effect of the mild skin disease, cowpox, found on the hands of the dairy workers, and kept records of those attacked by smallpox and those who escaped the disease. Finally Jenner felt he had enough evidence to attempt to duplicate, artificially, what had been going on in nature. He envisioned the time when he could make all people immune or resistant to smallpox by injecting them with the innocuous disease, cowpox. Before



EDWARD JENNER

SOME MEDICAL "FIRSTS" THROUGH THE YEARS

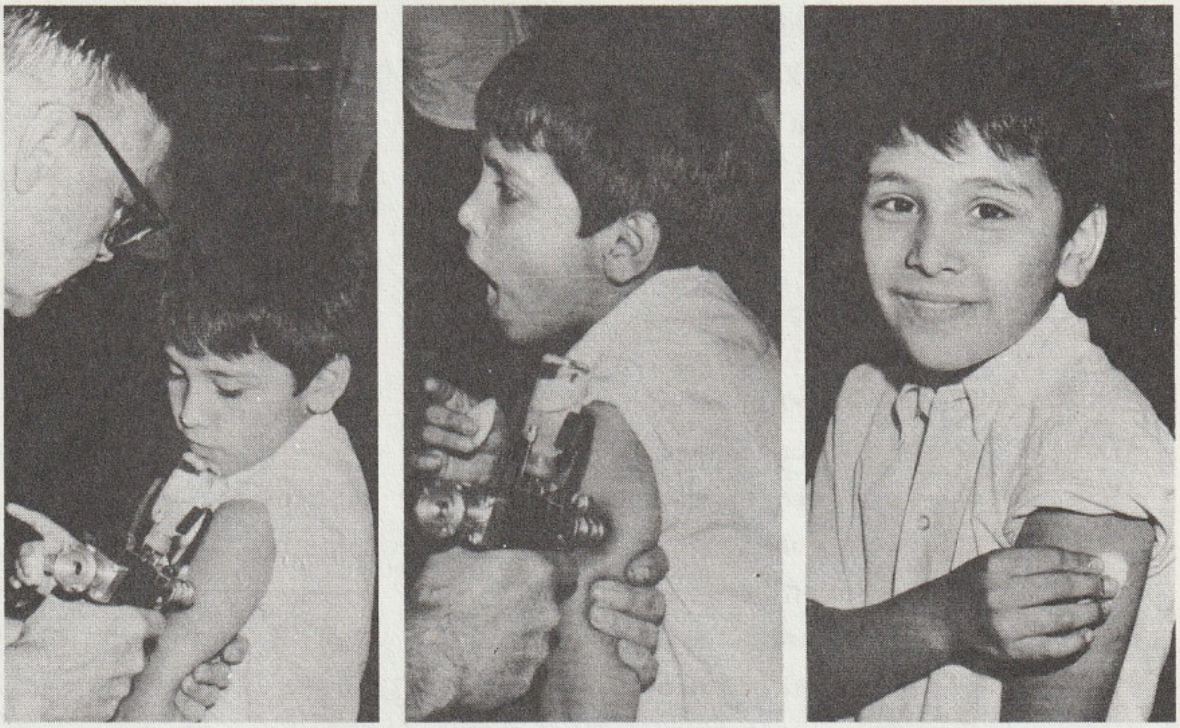
Year	Discovery	Discoverer
1628	Discovery of blood circulation	Harvey, England
1736	First successful appendectomy	Amyand, France
1796	First antitoxin vaccination	Jenner, England
1800	Founding of histiology—study of tissues	Bichet, France
1816	Invention of the stethoscope	Laënnec, France
1822	Description of digestive process	Beaumont, U.S.A.
1839	Establishment of cell theory	Schleiden-Schwann, Germany
1842	Use of ether as surgical anesthetic	Long, U.S.A.
1857	Development of pasteurization began	Pasteur, France
1865	Introduction of surgical antisepsis	Lister, England
1866	Invention of clinical thermometer	Allbut, England
1872	Founding of bacteriology	Cohn, Germany
1884	Discovery of diphtheria bacillus	Klebs-Loeffler, Germany
1885	Vaccination for rabies	Pasteur, France
1894	Discovery of bubonic plague bacillus	Yersin, France
1895	Founding of psychoanalysis	Freud, Austria
1895	Discovery of X rays	Roentgen, Germany
1901	Breakthrough against yellow fever	Reed, U.S.A.
1906	Development of test for syphilis	Wasserman, Germany
1912	Discovery of vitamins	Funk, U.S.A.
1915	Pellagra cure	Goldberger, U.S.A.
1928	Discovery of penicillin	Fleming, England
1932	First use of sulfa drugs	Domagk, Germany
1944	Discovery of streptomycin	Waksman, U.S.A.
1949	Use of cortisone in medical therapy	Hench, U.S.A.
1954	Development of hypodermic polio vaccine	Salk, U.S.A.
1961	Use of oral polio vaccine	Sabin, U.S.A.
1963	First use of artificial heart	DeBakey, U.S.A.
1967	First transplant of human heart	Barnard, South Africa
1969	Deciphering structure of gamma globulin	Edelman, U.S.A.
1970	First synthesis of the gene	Khorana, U.S.A.

this could be done, however, he had to experiment with human volunteers to be sure this method would work.

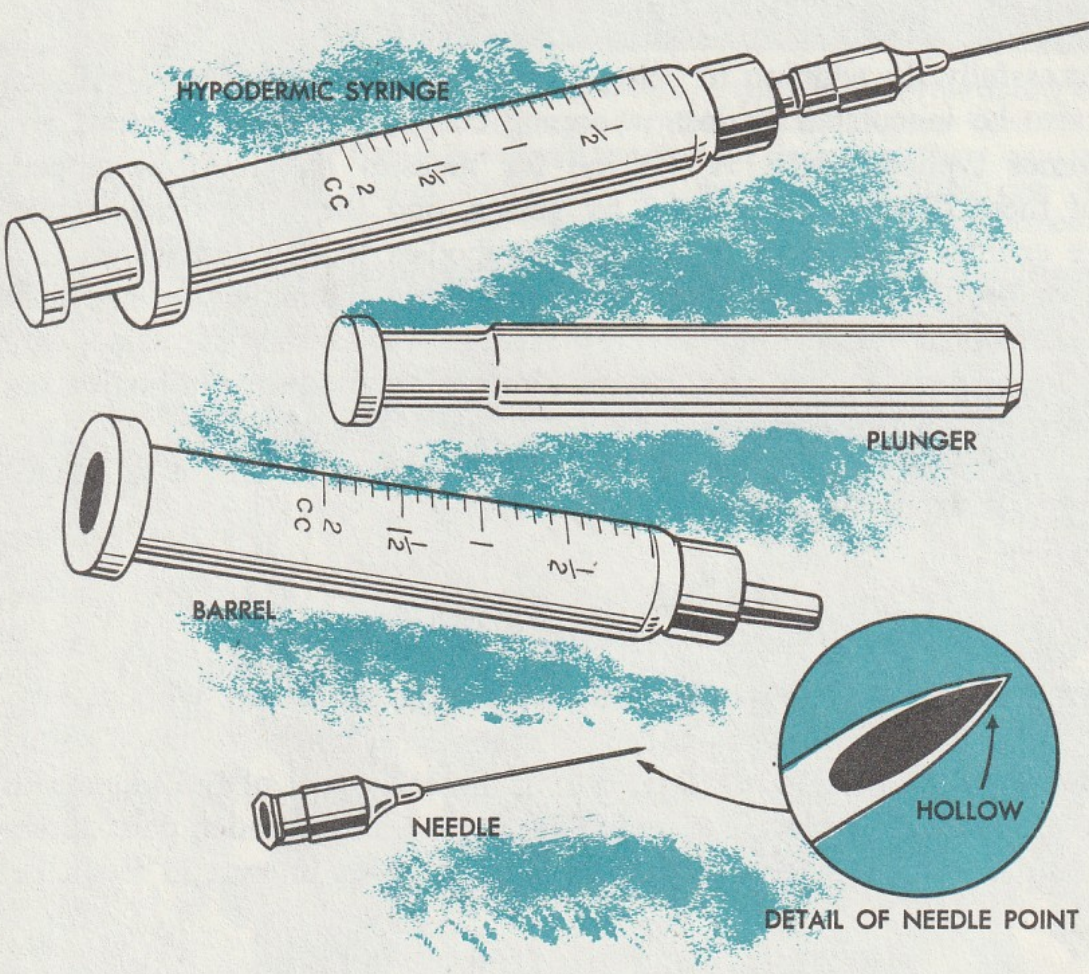
On 14 May, 1796, Dr. Jenner took some fluid from the sores on the hand of a milkmaid with cowpox and injected it into the arm of a healthy eight-year-old boy. This boy got a case of cowpox and in a few days recovered. Several weeks later this same boy was injected with smallpox fluid, but he did not get smallpox. Clearly, he was protected from it by the first *vaccination* with cowpox. Jenner set out to vaccinate more and more people. Those not first vaccinated with cowpox were sure to get smallpox on contact with a case of smallpox or fluid from a smallpox lesion or sore. Those vaccinated with cowpox were immune.

Therefore, the first successful vaccination for prevention of infection is credited to Dr. Edward Jenner. The British Parliament voted £30,000 to Jenner in gratitude for this great discovery. In 1808 his government placed him at the head of the National Vaccine Establishment. Jenner died in 1823, after practising medicine for fifty years.

Although Jenner did not know it at the time, he was practising the principle of immunity. Scientists today know that one of the ways the human body fights disease is to produce "antibodies" against invading



A small boy watches with interest as the doctor prepares to inoculate him during a diphtheria epidemic, reacts with a startled "ouch" to the shot given by the injection "gun", and recovers his composure quickly.



germs. Since cowpox virus is very similar to smallpox virus, the antibodies built up against the milder cowpox will also destroy the deadly smallpox virus. This means that Jenner's patients who had had cowpox were carrying cowpox antibodies that could also kill smallpox virus. In World War I the United States Army had four million soldiers vaccinated against smallpox. Of this group only fourteen deaths from smallpox resulted. This was a graphic example of the protective value of this vaccination.

Modern Vaccination and Immunity

TODAY'S HEALTH MEASURES to prevent disease take advantage of the contribution made by Jenner. Many people are vaccinated against smallpox at one year of age and periodically thereafter. The material used in the vaccination is closely related to the cowpox virus that Jenner used

so successfully. In addition to being vaccinated against smallpox, children may also be inoculated against whooping cough, diphtheria, tetanus and sometimes typhoid fever. A vaccine for measles has been developed. All of these diseases are caused by germs, and the immunization procedure enables each of us to produce antibodies to these germs so that when we are threatened by these microorganisms our antibodies can fight them off. In all these instances the vaccination material is treated with special chemicals so that the vaccination lets us produce antibodies but does not give us any disease.

One of the most interesting and very important vaccinations is against polio. This will be discussed later.

1800s—Painless Surgery

AS LATE AS THE 1830S SURGEONS performed operations without anything to prevent pain—except, sometimes, a bottle of strong spirits or a blow on the head. Therefore, during the early part of the nineteenth century, a great many people were looking for a way to deaden pain during surgical procedures. Since this problem was of major interest in medicine,

After surgery, patients are taken to a recovery room for close, personal care.

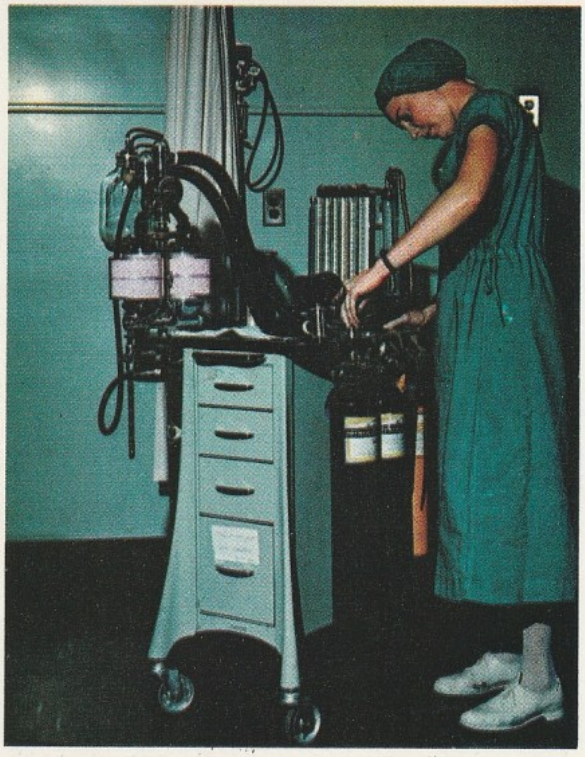
How Vaccines Have Helped Conquer Some Diseases

DISEASE	TISSUE AFFECTED	VACCINE AVAILABLE
Smallpox	Skin, mucous membrane	1796
Rabies	Central nervous system	1885
Yellow Fever	Liver	1917
Influenza	Respiratory system	1948 & 1957
Polio	Central nervous system	1953
Measles	Respiratory system	1963
Mumps	Salivary glands	1967
German Measles (Rubella)	Skin and glands	1969

it was not surprising that several people claimed to be the originators of ether for *anesthesia* during surgical operations.

It is generally accepted that Crawford W. Long of Georgia was the first man to employ ether to produce surgical anesthesia. In 1842 he persuaded one of his patients to inhale ether and then allow Long to remove a small tumor from his neck. This was done successfully and Long continued to perform minor operations with ether anesthesia. Since Long's medical practice was in a small town, his resourceful work attracted little attention and would have gone unnoticed were it not for the worldwide acclaim achieved by Morton after his demonstration of ether anesthesia in 1846.

During the 1840s William T. G. Morton was a successful dentist in Massachusetts with an interest in finding an agent that would make it possible to extract teeth without pain to the patient. As Morton investigated further, he felt the need to know more about medicine, and became a student of medicine in the offices of Dr. Charles T. Jackson, a chemist and physician.



6. ANESTHETIZING EQUIPMENT

An assistant prepares the equipment for an anesthesiologist.

During this era many students worked as apprentices to physicians while going to medical school. This was the case with Morton while he attended Harvard Medical School.

In the summer of 1844 Dr. Jackson suggested to Morton that ether might serve to deaden pain during dental extraction. On this advice Morton spent the next two years using ether on some of his dental patients. By 1846 Morton was so firmly convinced of the anesthetic value of ether that he decided to try to have it tested during a major surgical operation.

In October of that year Morton requested permission of Dr. John C. Warren to employ his anesthetic in a major operation. Dr. Warren was the chief surgeon of Massachusetts General Hospital and a noted figure of his time. His co-operation with Morton on ether as an anesthetic provided more general acceptance by surgeons of the day than would have resulted from Morton's work alone, since Morton was a dentist and still only a medical student.

The day finally set for the major test of ether as an anesthetic was 16 October, 1846. Dr. Warren and a board of the most eminent surgeons in Massachusetts were gathered around the patient, a Mr. Gilbert Abbott.

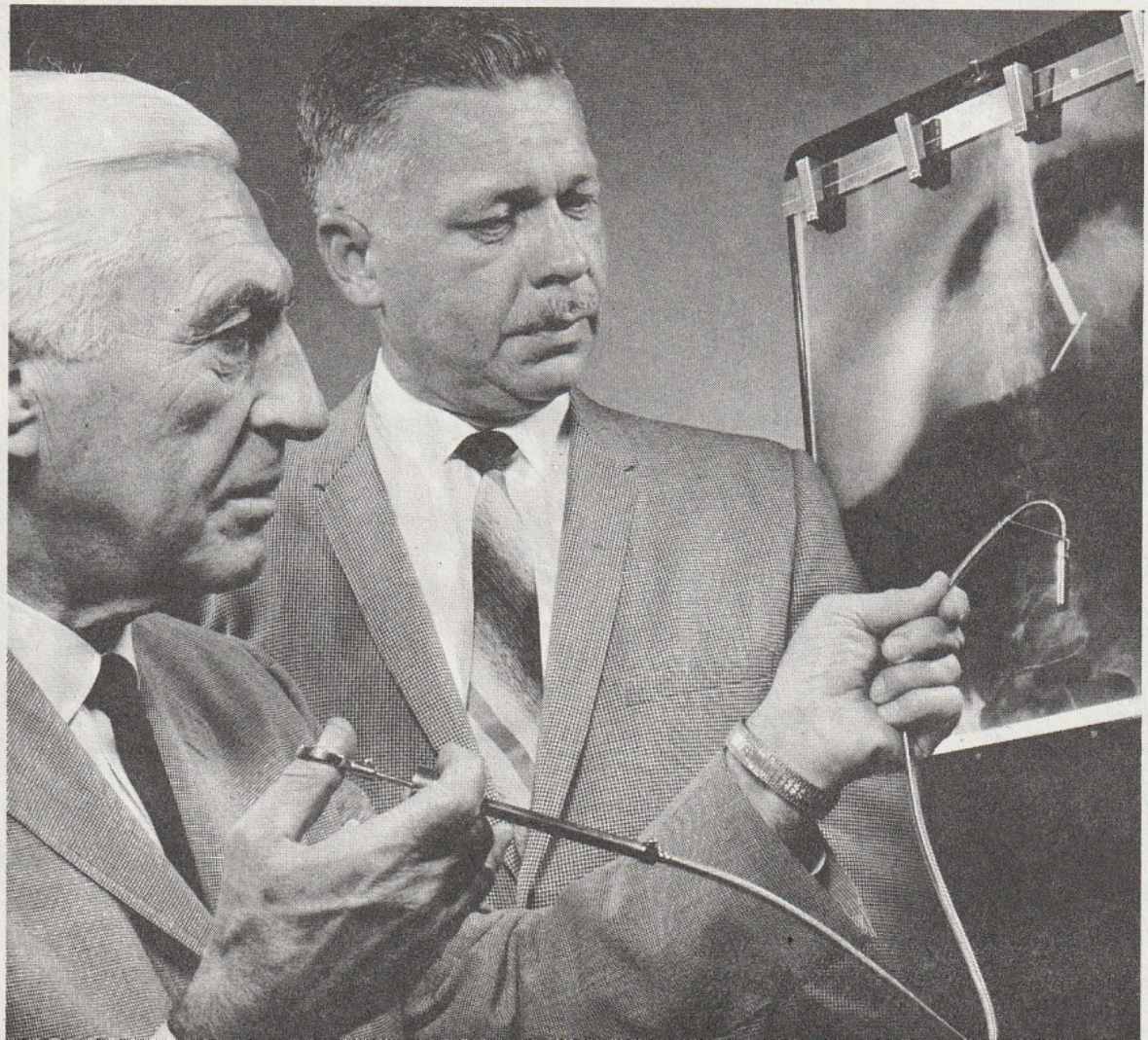
The operation was for the removal of a tumor on his neck. Dr. Morton applied the ether and the surgeons operated. When the patient recovered consciousness, he declared that he had suffered no pain. Dr. Warren turned to the distinguished audience and said, "Gentlemen, this is no humbug."

This case is remarkable in the annals of surgery. It was the first widely reported major surgical operation performed with a satisfactory agent that kept the patient from feeling pain.

Soon after this operation the Massachusetts General Hospital adopted ether for almost all of its surgical procedures. Scientific journals published the description of this new procedure, and as early as December of 1846 ether was administered by surgeons in Paris and in England.

Ever since the historic operation by Dr. Warren there has been a controversy whether Long, who used ether in 1842 in Georgia, or Morton,

A painless recovery. Doctor demonstrates a steerable medical magnet that can recover swallowed iron objects from previously inaccessible regions of the stomach.



A painting of Original Ether Day, Boston, 16 October, 1846. On the left, Dr. Morton is seen holding the inhaler while Dr. John Warren removes a tumor from the neck of Gilbert Abbott, before an audience.

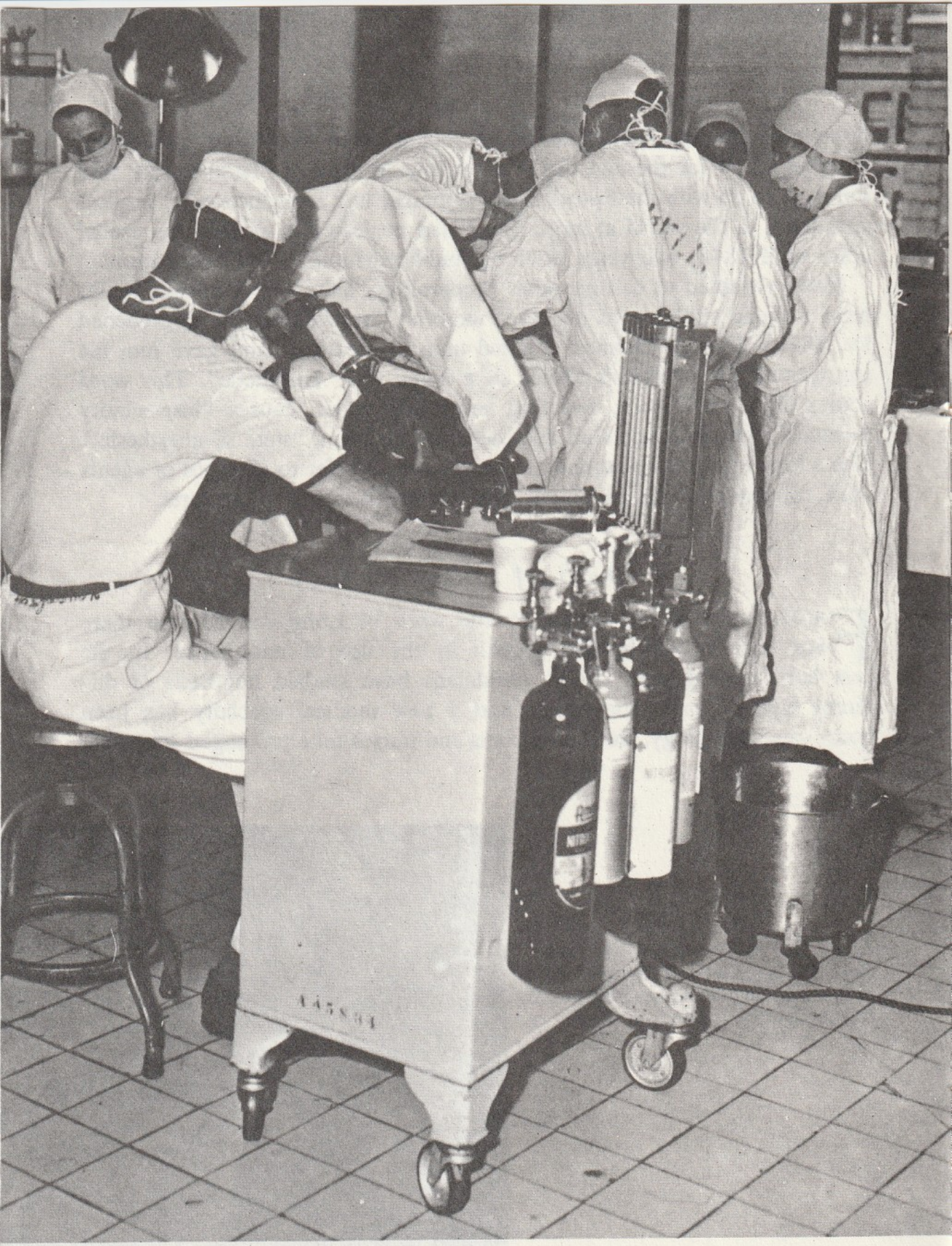
discovered surgical anesthesia. Most people agree that Long of Georgia deserves credit for the first use of ether, but Morton of Massachusetts had the most to do with the historical development and introduction of surgical anesthesia to the world at large. Long had neglected to publish his use of ether until 1848, two years after the public demonstration by Morton.

Morton wanted to call his ether preparation "letheon", so that it would have a name applying to no other material. Accordingly, he approached Dr. Oliver Wendell Holmes, a noted man in medicine, and gave him his suggestions. Dr. Holmes's choice of a name was "anesthetic". This word comes from the Greek, meaning something which causes "insensibility to touch"; one who takes an anesthetic is put into a "state of anesthesia". These terms were adopted and are used today to refer to all types of agents used to deaden pain in dental and medical-surgical procedures.

Growth of Anesthesiology

FROM THE IMPETUS GIVEN by the work of Long and Morton there has been a step-by-step growth in the use of anesthetics. In the past hundred-odd years, many physicians have studied hundreds of different type of anesthetic agents and a new medical specialty has been born—anesthesiology. Both physicians and nurses take prolonged schooling

After the inhaler came the mask. Here the anesthetic is dropped at a controlled rate onto an absorbent mask and the patient breathes in the fumes.



Anesthetic equipment is seen in use during an operation. The anesthesiologist holds the mask and the breathing bag.

in this special field. With proper training, they are able to administer anesthetics for surgeons just before operations.

Although ether and chloroform are perhaps the best known of the anesthetics, there are many, each with its special function for deadening pain. Some anesthetics are inhaled, some are injected into the vein, others are injected into the spinal column, and still others are used topically, on the surface of the skin. Certain of these are called *general anesthetics* because they are effective over the entire body. Others are called *local anesthetics* because they prevent pain over the small area where they are injected. However, all anesthetics have the important function of making surgical procedures painless. They are responsible for the expansion of all fields of surgery. One of the great discoveries in medicine is anesthesiology, thanks to Long and Morton.

Science Bulletin
Prepared by SCIENCE SERVICE

NEW COLD DRUG

The number and diversity of cold viruses virtually makes impossible the control of colds by conventional vaccines. So probably the only hope for an effective cold treatment lies in the development of broad-acting viral drugs.

A drug that strikes twenty-five different cold viruses in human lung cells was reported by R. A. Bucknall and his colleagues at Imperial Chemical Industries in England.

The drug, an organic compound, does not destroy cold viruses nor keep them from entering the cells. Rather, it prevents the viruses from synthesizing more viruses in the infected cells.

CONSCIOUS CONTROL OVER HIGH BLOOD PRESSURE

Deaths from heart attacks are proportional to blood pressure increases. There are many drugs to lower blood pressure, but they carry serious risks, such as deafness, glaucoma and depression. So it would be a great advance if patients could lower their blood pressure by means other than drugs.

In 1969 a team of investigators noted that yoga exercises could help reduce high blood pressure. C. H. Patel, a physician in Croydon, England, decided to try yoga on twenty of his patients suffering from hypertension or high blood pressure.

The patients came to see Patel three times a week for three months. They lay on a couch with an instrument called a relaxometer hooked up to them that transmitted their sympathetic nerve activity into radio signals. Sympathetic nerves are believed to play an intermediate role in producing high blood pressure. If the radio signals increased in pitch, they indicated that the patients were excited. If the signals decreased in pitch, they indicated that the patients were relaxing. As the patients practiced yoga exercises to relax themselves physically and mentally, they also made a conscious attempt to reduce the pitch of the signals emanating from their bodies.

At the end of the study, five patients could stop taking drugs to reduce hypertension altogether, while seven were able to reduce drug use thirty-three to sixty per cent. Blood pressure control was better in four other patients, while four patients did not respond. "The results," Patel said, "promise a useful new approach to the treatment of hypertension."

ROLE OF MESSENGER RNA IN HEREDITY

Deoxyribonucleic acid (DNA) contains the genes of a cell. Messenger ribonucleic acid (MRNA) translates its instructions into proteins. But apparently MRNA, exclusive of DNA, can influence cell differentiation and the passage of inherited characteristics, Niu Manchiang of Temple University and Tung Ti-chou of the Chinese Academy of Sciences have found.

The American and Chinese biologists extracted MRNA from mature carp eggs, purified it, then injected it into freshly fertilized goldfish eggs. Of the 320 fry born, 106 had a single tail fin, characteristic of carp. Goldfish have a double tail fin. These results, the biologists say, show that MRNA plays a significant role in cell differentiation and heredity.

This is the first significant scientific result to emerge from a co-operative effort between American and Chinese scientists since the United States re-established relations with mainland China.

SKINNER CONDITIONING LESSENS PAIN

Psychologist B. F. Skinner's concept that conditioning can modify one's behavior is being used not just in psychology, but in traditional medical science.

Wilbert E. Fordyce and his team of rehabilitation medicine specialists at the University of Washington School of Medicine decided to view chronic pain as learned behavior instead of as physiological pathology (the classic view). They selected thirty-six patients with chronic pain for a four-year study. During the study they attempted to lessen the patients' pain by conditioning. They encouraged the patients to stop talking about their pain, to reduce their intake of pain-killing drugs, to get more exercise and to work and socialize more. When the study ended, the patients said they suffered considerably less from pain, the investigators reported.

"More work," they conclude, "is needed to identify in more detail the factors which indicate a patient's pain behavior is under control of environmental consequences rather than of tissue pathology."

TRACE ELEMENTS AND APPETITE

Undersized, run-down children who hate to eat, or adults who say that everything they eat tastes like sawdust, have often been judged psychosomatic by physicians. That is, their poor eating habits have been attributed to psychological problems rather than to a physical disturbance.

Robert I. Henkin and his co-workers at the National Heart and Lung Institute questioned this assumption and set out to see whether poor eating might be a physical problem. They cut hair samples from seventy-five undersized children who were poor eaters and examined the samples for levels of zinc. The levels were low compared to the traces of zinc found in the hair of healthy children. They then fed the children liver, kidney and other zinc-rich organ meats for one month.

The children's appetites showed marked improvement; apparently the zinc supplements improved their senses of taste and smell.

Henkin said, however, that zinc deficiencies are probably not the only cause of poor eating. Copper and nickel deficiencies may be culprits as well.

KANGAROO HOPPING: ONE ENERGY SOLUTION

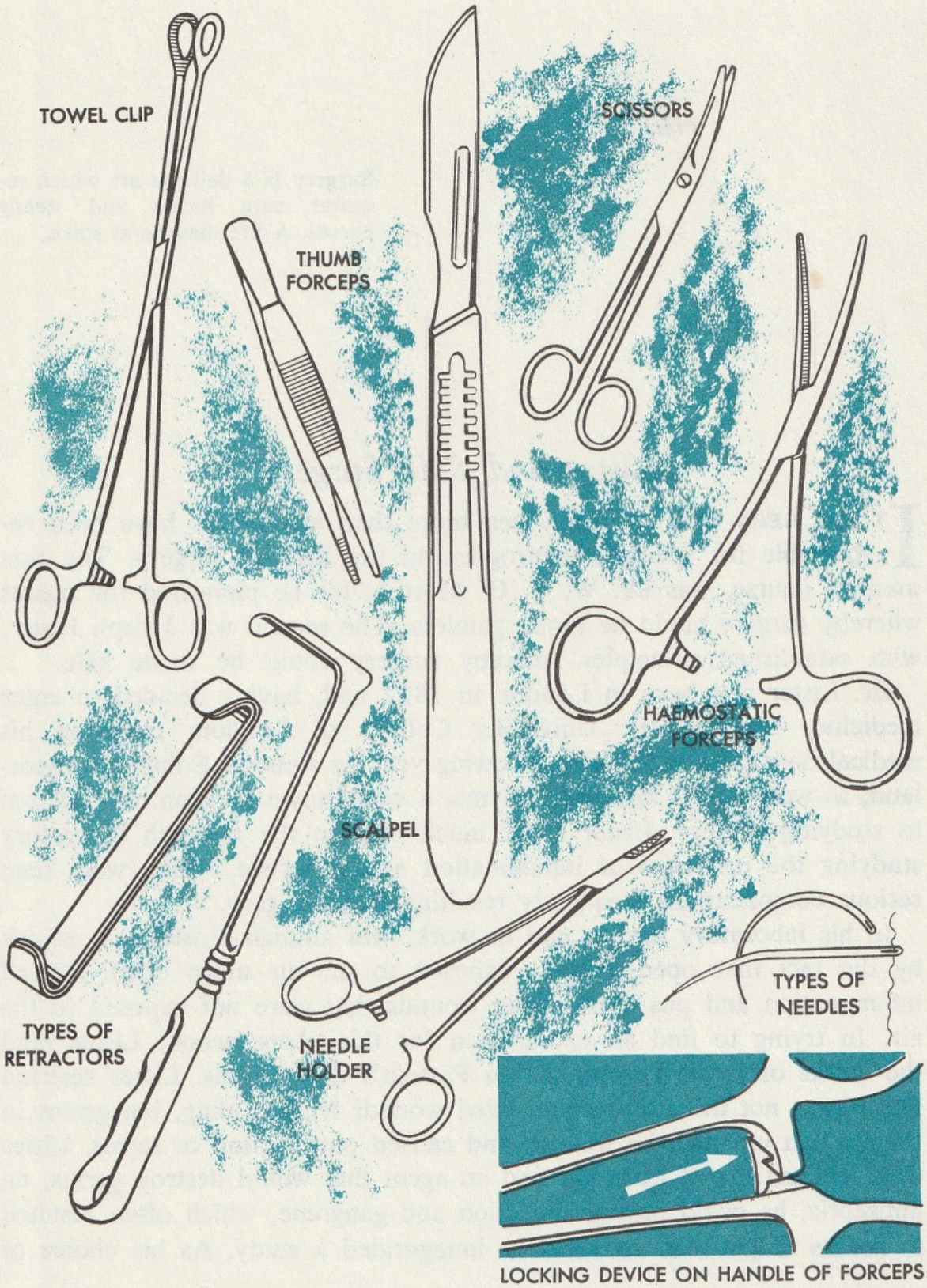
When kangaroos hop, they look like bouncing balls or pogo sticks. Such movement suggests that the first hop takes a lot of energy, but subsequent hops rely mostly on elastic rebound. If so, kangaroo hopping should be an energetically cheap way to travel at high speeds.

Harvard biologists Terence J. Dawson and C. Richard Taylor set out to see whether this is so. They trained two kangaroos to hop on a treadmill while wearing ventilated face masks. While the animals hopped at various speeds, the biologists measured their oxygen consumption—a reflection of the amount of energy they were expending.

The biologists found that while the distance per hop increased with increasing speed, the amount of energy per hop was nearly constant. So the animals achieved greater acceleration on takeoff as they moved faster without expending more energy. They were probably able to do this because of the great stores of energy in their rear limbs and heavy tails, which they sometimes used as a fifth leg.

Having one's appendix removed is no longer considered a major operation, but it still requires this array of sterilized surgical instruments.

TYPICAL SURGICAL INSTRUMENTS



7. IN SURGERY

Surgery is a delicate art which requires sure hands and steady nerves. A life may be at stake.

Lister and Safe Surgery

IT HAS BEEN SAID that two men more than any others have been responsible for spectacular progress in the field of surgery. The first man, of course, was Dr. W. T. G. Morton, for he pioneered the means whereby surgery could be made painless. The second was Joseph Lister, who established principles whereby surgery could be made safe.

Dr. Lister was born in London in 1827 and, having decided to enter medicine, attended the University College of London, receiving his medical degree in 1852. The following year he went to Edinburgh, Scotland, to work under Dr. James Syme, a well-known surgeon. In addition to studying surgery, Lister spent much time in the research laboratory studying the processes of inflammation and gangrene, which were then serious complications frequently resulting from surgery.

In his laboratory studies and in work with animals, Lister was struck by the fact that open wounds exposed to the air more often showed inflammation and pus than closed wounds that were not exposed to the air. In trying to find an explanation for this phenomenon, Lister read the works of Louis Pasteur. From Pasteur's descriptions, Lister realized that it was not the air that prevented wounds from healing, but germs in the air that infected the wounds and caused putrefaction or sepsis. Lister then realized that if he could find an agent that would destroy germs, an antiseptic, he could prevent infection and gangrene, which often resulted in deaths of patients. In 1865 he inaugurated a study. As his choice of

an antiseptic, Lister selected carbolic acid. He dipped a piece of cloth into germ-killing carbolic acid and then with forceps placed the cloth in the wound. A second, similar piece of cloth was placed over the wound to seal it. During almost a year of following this procedure in his hospital wards, Lister found not a single case of gangrene or putrefaction in a wound. The other wards at the hospital had many cases!

Lister immediately recognized that this antiseptic principle could be applied to the entire practice of surgery, and in 1865 he published a paper in the *British Medical Journal* on this subject. In addition to describing carbolic acid treatments of various wounds, such as fractures, abscesses and ulcers, Lister recommended the use of carbolic acid throughout the hospital. He recognized that the air, floors, instruments, linens, clothing and all objects could carry germs, and that these items should not be allowed to contact wounds unless they had been treated with carbolic acid.

In England, Lister's ideas were not received with much enthusiasm at first, but on the Continent renowned surgeons quickly accepted his recommendations. In France, Germany and Denmark his ideas were followed and successes were achieved.

Attendant applies spray-on instrumentation used to transmit, by radio-telephone, a heart patient's electrocardiogram (ECG) measurements from the ambulance to the receiving hospital.

This is an actual photograph taken in the 1870s during an operation in a ward at Bellevue Hospital, New York City. Notice how much has changed since then. There were no rubber gloves, no face masks, no sterilized caps or gowns—and other patients could watch the excitement!

Finally, in 1883 Lister was recognized by his native country. He was elected to the Royal Society, became Lord Lister, received medals and general acclaim. He died in 1912, respected by the world.

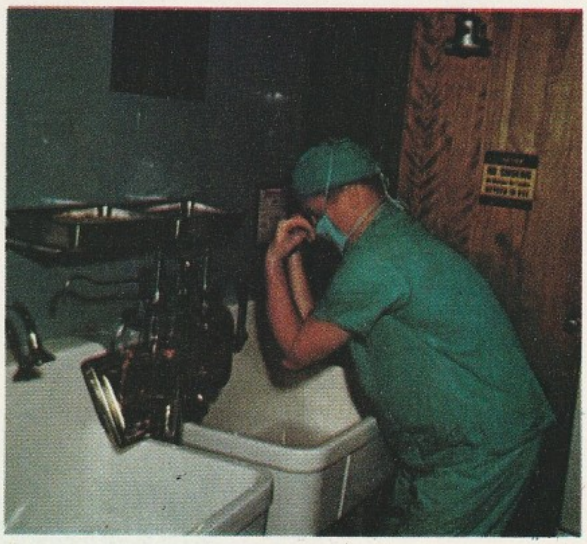
Freedom from Germs

BECAUSE OF LESSONS learned from history, today's modern hospitals are operated with a vital principle in mind—to maintain freedom from germs whenever and wherever possible.

Cleaning of floors, walls, utensils, linens and bedding in hospitals is made with the aim of eliminating germs. Disinfectants, which are germ-killing chemicals, are used throughout hospitals on inanimate objects, while antiseptics, which are germ-killing agents, are used on the bodies of surgical, medical and other hospital patients regularly.

In addition, it is routine procedure to sterilize all instruments, bandages and dressings that are to be in contact with wounds. Many of these materials are sterilized not by chemicals but by placing them in steam-pressure sterilizers called autoclaves. These autoclaves create conditions which destroy all germs. Linens and dressings so treated are safe when in contact with open wounds.

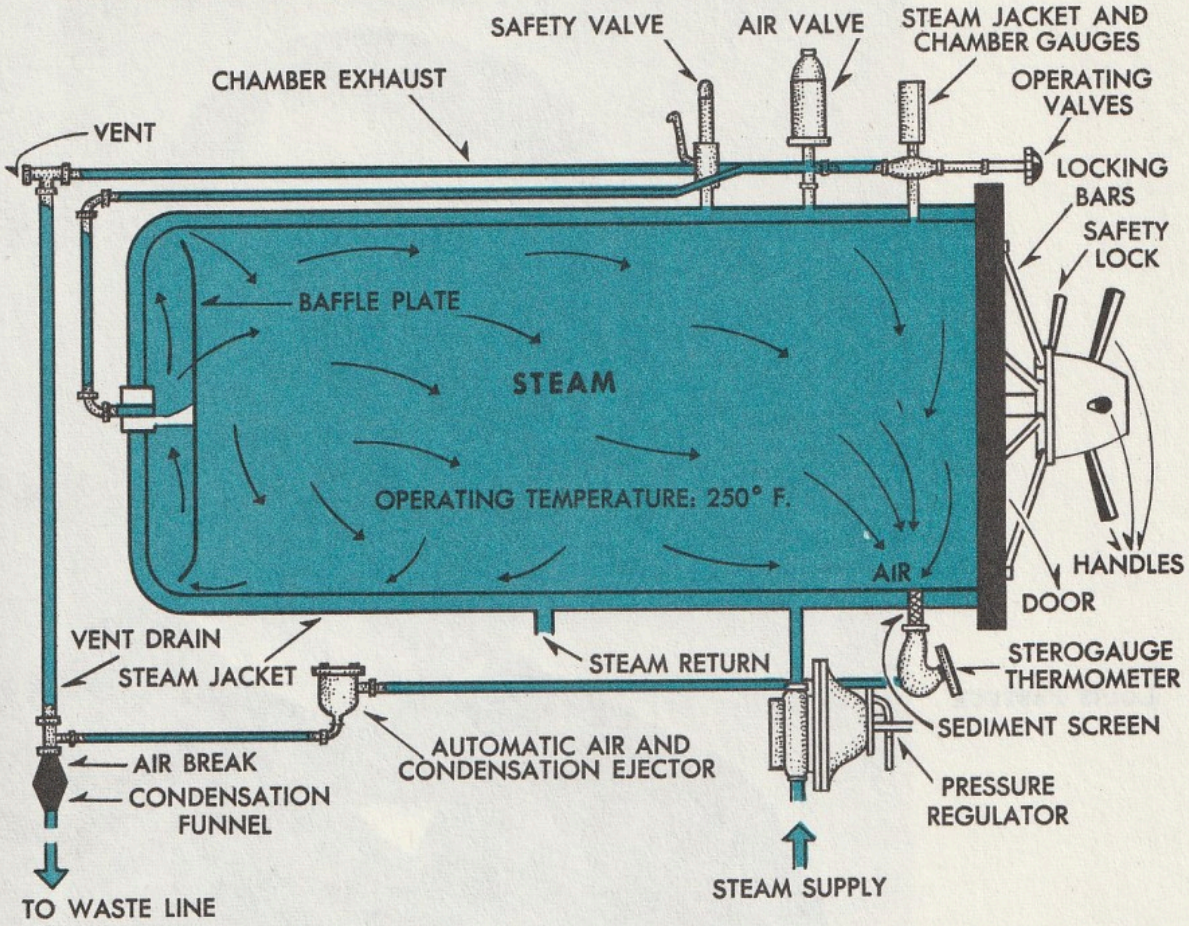
All these techniques are invaluable because they help to decrease the number of infections that may develop in wounds following surgery. They prevent hospital infections from being transmitted from one patient to another and they help maintain rigid sanitary conditions which are essential to good health.



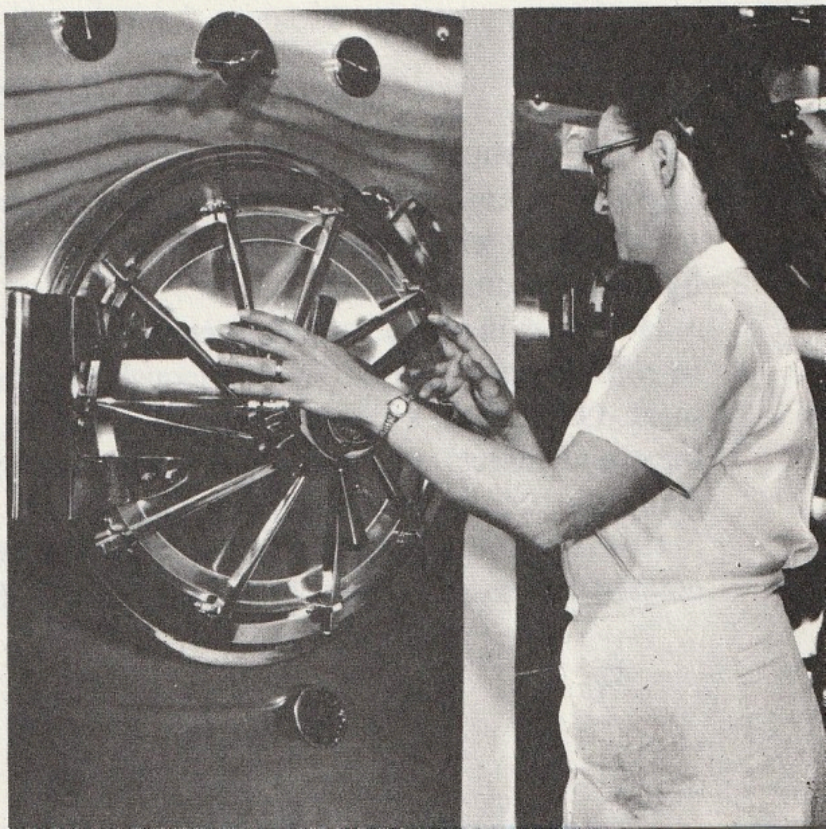
9 SCRUBBING UP

Scrubbing up is one of the vital preliminaries to any operation. Here a doctor rinses his arms under running water after he has scrubbed them with disinfectant for as long as twenty minutes.

CUTAWAY DIAGRAM OF AN AUTOCLAVE



Surgical instruments must be not only clean but completely free of all germs—sterilized. This is done by steam in an autoclave shown in cross section in the diagram above.



LOUIS PASTEUR

Pasteur and Bacteriology

THROUGHOUT THE ANCIENT CIVILIZATIONS it was believed that some worms, insects and vermin could somehow be bred from nonliving materials. This was called *spontaneous generation* and the belief was held by many prominent men.

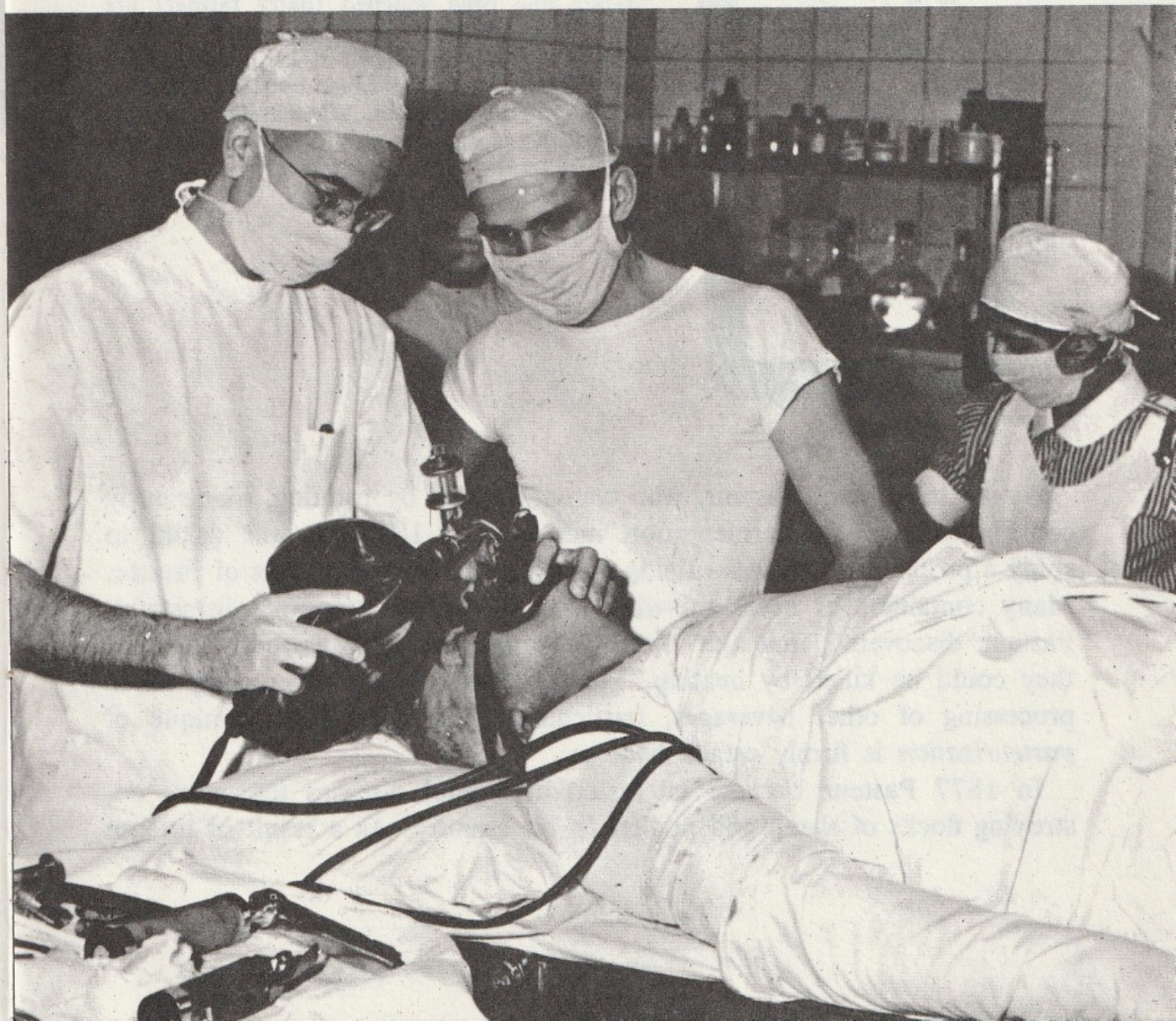
However, in the seventeenth century Francesco Redi proved that worms in rotting meat rose not spontaneously but out of eggs laid by flies on the meat. Other men, such as Spallanzani and Appert, proved that tapeworms, mice and insects all came from living specimens of the same species and could not come from nonliving filth.

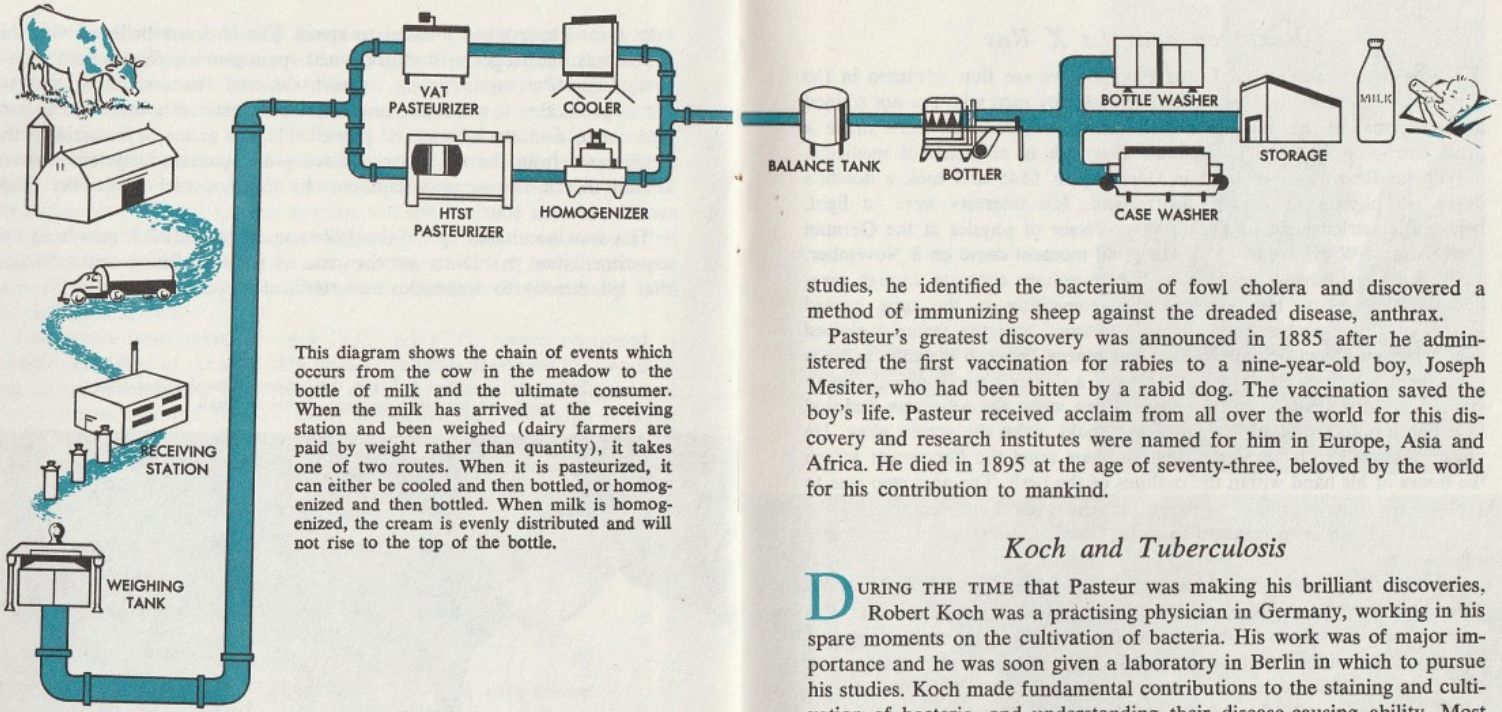
It was in the nineteenth century that the contributions of Louis Pasteur entered history. Chemists had observed that fluids such as milk, wine and

beer turned sour when allowed to stand. The chemists believed that this action was due to germs that originated spontaneously in the fluid. However, Louis Pasteur, a young chemist, doubted this conclusion and set out to prove that it was false. In a series of experiments that Pasteur carried out in a masterful way, he proved that the germs or bacteria in the fluids came from the air and could not arise spontaneously. He demonstrated that if the air was kept out, by using special flasks, the fluids would not turn sour.

This was the ultimate proof that "life comes from life." It was from this experimentation that Lister got the ideas on surgical wound contamination that led directly to antiseptics and sterilization of air.

Before an operation is begun the patient is anesthetized. Here the mask and breathing bag are shown in detail.





This diagram shows the chain of events which occurs from the cow in the meadow to the bottle of milk and the ultimate consumer. When the milk has arrived at the receiving station and been weighed (dairy farmers are paid by weight rather than quantity), it takes one of two routes. When it is pasteurized, it can either be cooled and then bottled, or homogenized and then bottled. When milk is homogenized, the cream is evenly distributed and will not rise to the top of the bottle.

As we have seen, Pasteur, who was a chemist by training, made early contributions to the fermentation industry. In 1864 he was asked to study a problem which was ruining the wine and beer industries of France. Many containers of beer and wine were becoming sour and distasteful. Pasteur discovered that the wines were spoiled by microbes and that they could be killed by heating. This process has now been adapted to processing of other beverages, particularly milk, and the technique of *pasteurization* is firmly established.

In 1877 Pasteur became interested in animal diseases that were destroying flocks of sheep and poultry in his country. As a result of intense

studies, he identified the bacterium of fowl cholera and discovered a method of immunizing sheep against the dreaded disease, anthrax.

Pasteur's greatest discovery was announced in 1885 after he administered the first vaccination for rabies to a nine-year-old boy, Joseph Mesiter, who had been bitten by a rabid dog. The vaccination saved the boy's life. Pasteur received acclaim from all over the world for this discovery and research institutes were named for him in Europe, Asia and Africa. He died in 1895 at the age of seventy-three, beloved by the world for his contribution to mankind.

Koch and Tuberculosis

DURING THE TIME that Pasteur was making his brilliant discoveries, Robert Koch was a practising physician in Germany, working in his spare moments on the cultivation of bacteria. His work was of major importance and he was soon given a laboratory in Berlin in which to pursue his studies. Koch made fundamental contributions to the staining and cultivation of bacteria, and understanding their disease-causing ability. Most important of his discoveries was the organism that causes tuberculosis. He isolated and identified the tubercle bacillus as the cause. In 1883 Koch was investigating diseases in Egypt, and discovered the organism causing human cholera and the method by which it was transmitted in food and water. Koch also investigated plague, conjunctivitis (eye inflammation), malaria and sleeping sickness. To the study of all of these he made valuable contributions.

Koch was one of the greatest bacteriologists in history. Colleagues came from all over the world to work in his laboratory, and later work in bacteriology in the United States was led by men who had studied with him. His techniques and procedures are used in laboratories to this day.

Roentgen and His X Ray

FROM THE EXAMPLE OF LOUIS PASTEUR we see that advances in the field of medicine and health can be made by men who are not trained as physicians. In this manner a well-known university physicist made a great discovery that was to facilitate diagnosis in all fields of medicine.

Wilhelm Roentgen was born in Germany in 1845 and took a doctor's degree in physics at Zurich, Switzerland. His interests were in light, heat and electricity and he became a professor of physics at the German University of Würzburg in 1885. His great moment came on 8 November, 1895. He was studying the passage of high-voltage currents through rarefied-gas-filled tubes. He observed that something in the tube caused a glow on fluorescent material. Roentgen found that the material glowed even when an object opaque to light was placed between the tube and the fluorescent material. However, the form of a denser opaque object (lead) showed up as a shadow on the screen. Even when the tube was enclosed in a lightproof cardboard box, the rays could make the screen glow. He placed his hand in front of the tube and saw upon the fluorescent screen the bones of his hand within the outlines of the flesh. The next step was to replace the fluorescent, or glowing, screen with a photographic plate and thus obtain a permanent picture. Roentgen called his newfound rays *X rays.*

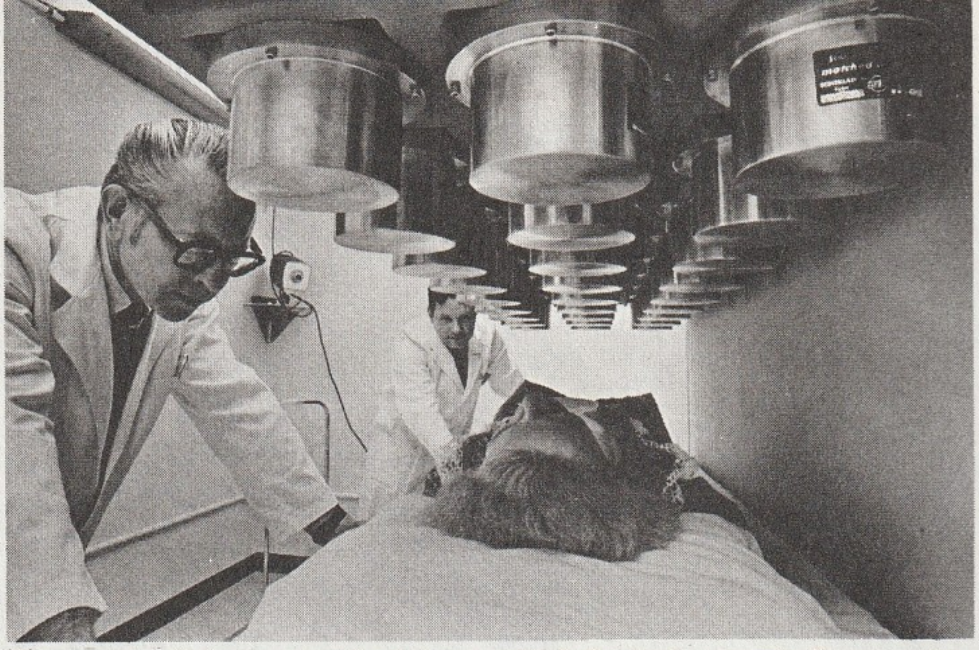
The surgeons and physicians of Europe were overwhelmed when Roentgen announced his discovery to the public. Two years after this discovery, X rays were in use around the world to help make diagnoses of surgical conditions such as fractures, gastrointestinal obstructions and bullet wounds suffered in military engagements. Roentgen's work was extended by others until dozens of possible uses of X rays were developed. Roentgen was awarded the Nobel Prize in Physics in 1901 for his great accomplishment.

This discovery was one of the first involving radioactivity, or the study of the atom as applied to medicine. In reality it was a beginning step in what much later was to be called nuclear medicine.

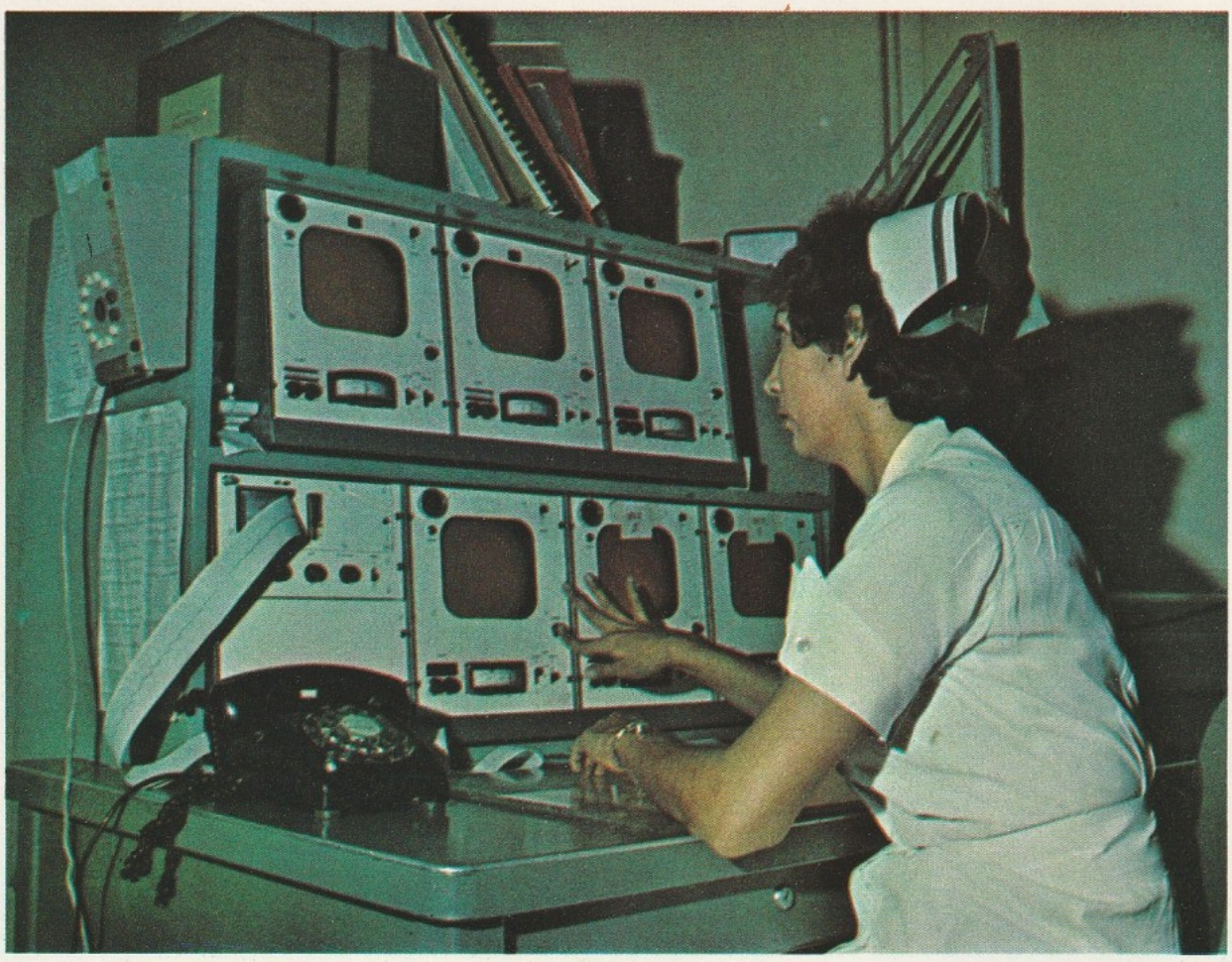
The Use of Radioactive Isotopes

STARTING WITH THE X RAY and information provided by the discovery of radium by Madame Marie Curie and her husband Pierre, and with improvements to the devices which generate radiation, the applica-

In the laboratory (*below*) at University of Würzburg in Germany, Wilhelm Konrad Roentgen conducted the experiments which led to his discovery of X rays on 8 November, 1895.



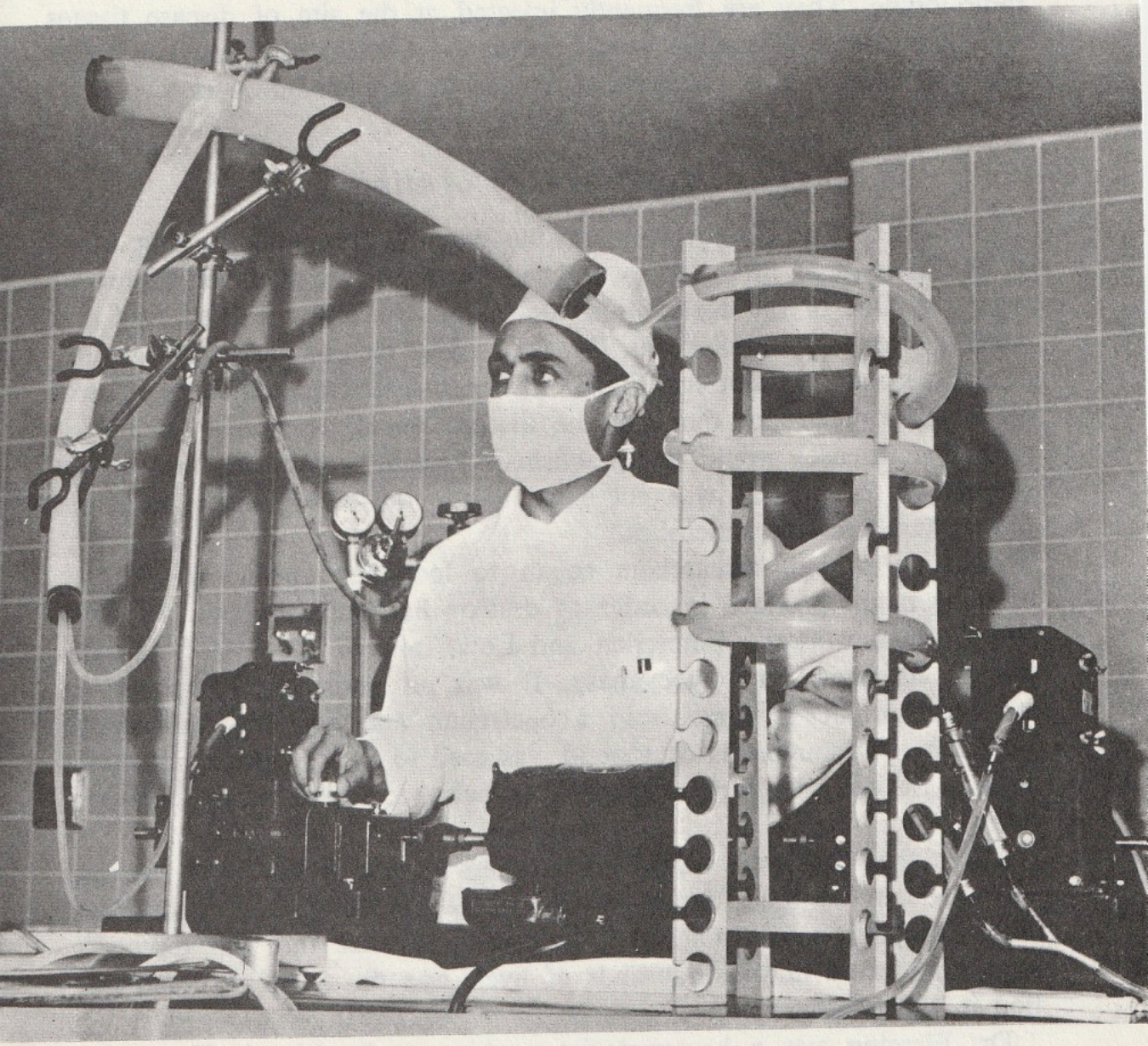
Doctors explain to a patient how a "whole body counter" measures precisely the amount of calcium in her skeleton.



10. CARDIAC MONITORING SYSTEM

On the TV screens of this machine the nurse in attendance can keep track of a continuous heart wave form for each patient in the intensive care unit. The monitoring system also records pulse and respiration and has alarms to alert personnel to any changes.

tion of radioactivity to medicine has become highly developed. It was observed in many experiments that if certain chemical elements, such as iodine, phosphorus, gold and others, were subjected to bombardment by nuclear particles in an atom smasher (more recently in a reactor), these elements became radioactive and gave off their own rays. Because these rays can be detected with extreme sensitivity by special apparatus, and



Shown here is an oxygenator-pump, one of the vital components in a heart-lung machine, used in pioneering advances in heart surgery.

because some of them have a potent biological effect, two important medical uses of radioactivity have been established. One of these involves radioactive tracers in which minute amounts of radioactive isotopes are taken into the body with their nonradioactive twin elements, and then traced by the rays which they give off. This enables physicians to study how the body is handling and disposing of a wide variety of compounds. Since some radioactive compounds give off potent rays that can kill disease tissue, they are also used as therapeutic agents to treat disease. Examples of these compounds are radio-gold, radio-phosphorus and radio-iodine. They are frequently injected at the site of disease tissues and their potent rays serve to kill the tissue. Certain radioactive isotopes are now used in the treatment of cancer to supplement X rays.

The Discovery of Antibiotics

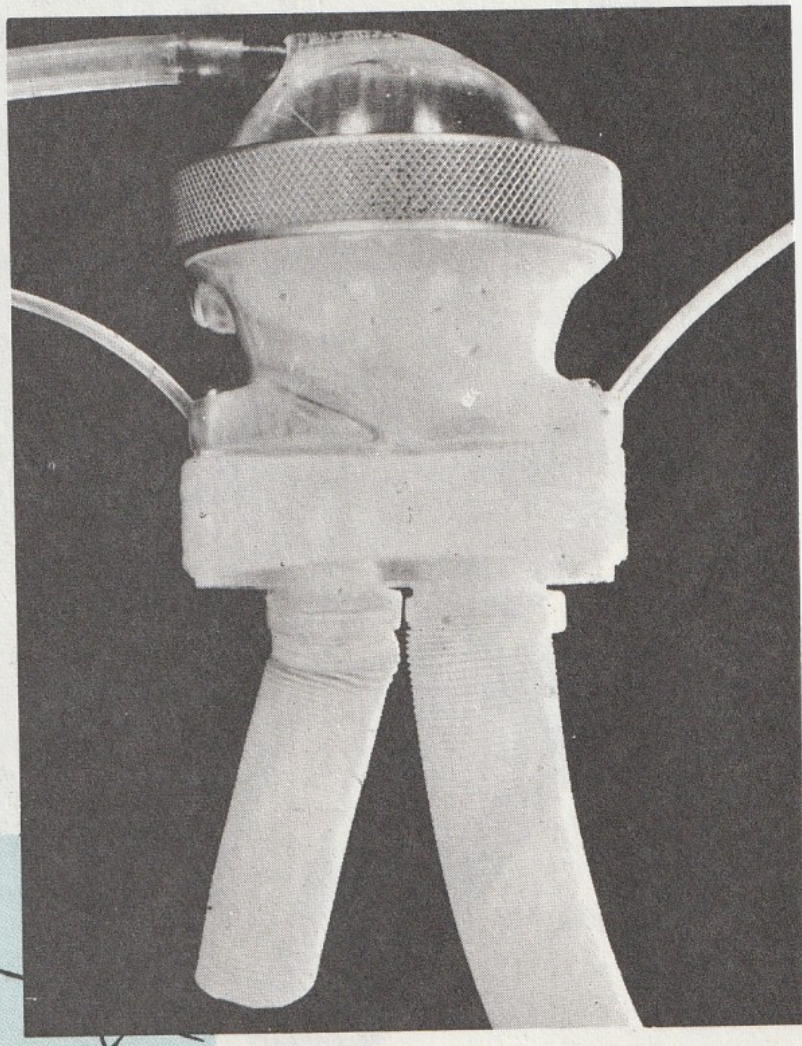
AS WE HAVE LEARNED from previous examples, seemingly unimportant observations often led to practical results which had benefit for all mankind. One of the observations that Louis Pasteur recorded was that some germs—or microbes, as they are often called—fight and destroy other microbes. Pasteur felt that if man could find a method to control those useful microbes that kill the disease microbes, a way of curing microbial diseases would be established. Pasteur's idea was sound, but the science of his day was not equal to the job of organizing microbes for warfare on other microbes.

As time passed, researchers began to look for chemicals which a microbe might produce in order to destroy harmful microbes. In 1901 two German workers, Emmerich and Low, isolated the first such compound. Its name was pyocyanase. It was an antiseptic compound of microbial origin. It came from a bacterium and was the first of the *antibiotics*. Although this compound was used to treat bacterial infections of man, it was ultimately discarded as being too toxic when taken internally.

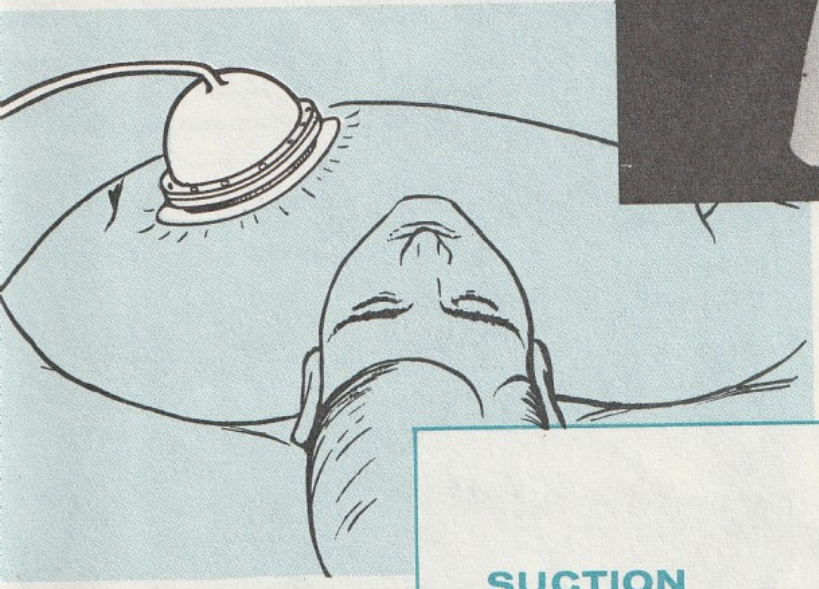
There then followed almost thirty years during which little progress was made in antibiotic work—until the magnificent discovery of Alexander Fleming, a Scotsman. It is amazing to realize that this discovery, which has saved untold thousands of lives, was the result of contamination in the laboratory.

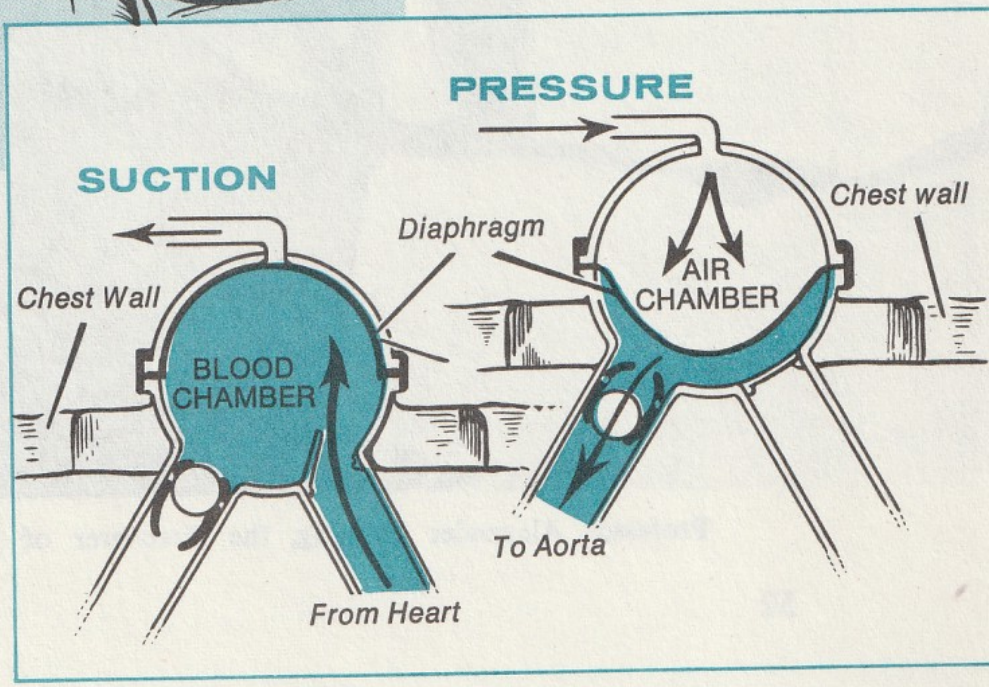
Dr. Fleming was a bacteriologist working at St. Mary's Hospital in London. One day in 1928 he noticed that a mold was growing on one of

The heart pump which Dr. Michael De Bakey of Texas implanted in the 1960s in several patients with severely damaged hearts is shown in the photograph at right. The pump consists of a plastic dome about the size of a grapefruit. It rests on the patient's chest (*below*), with nylon tubes connected to the heart and to a twenty-five-pound motor at bedside.



The diagram (*lower right*) shows how alternate suction and pressure applied to the pump through a tube leading from the machine outside the body force the blood from the heart and through the aorta to the rest of the body.





Professor Alexander Fleming, the discoverer of penicillin.

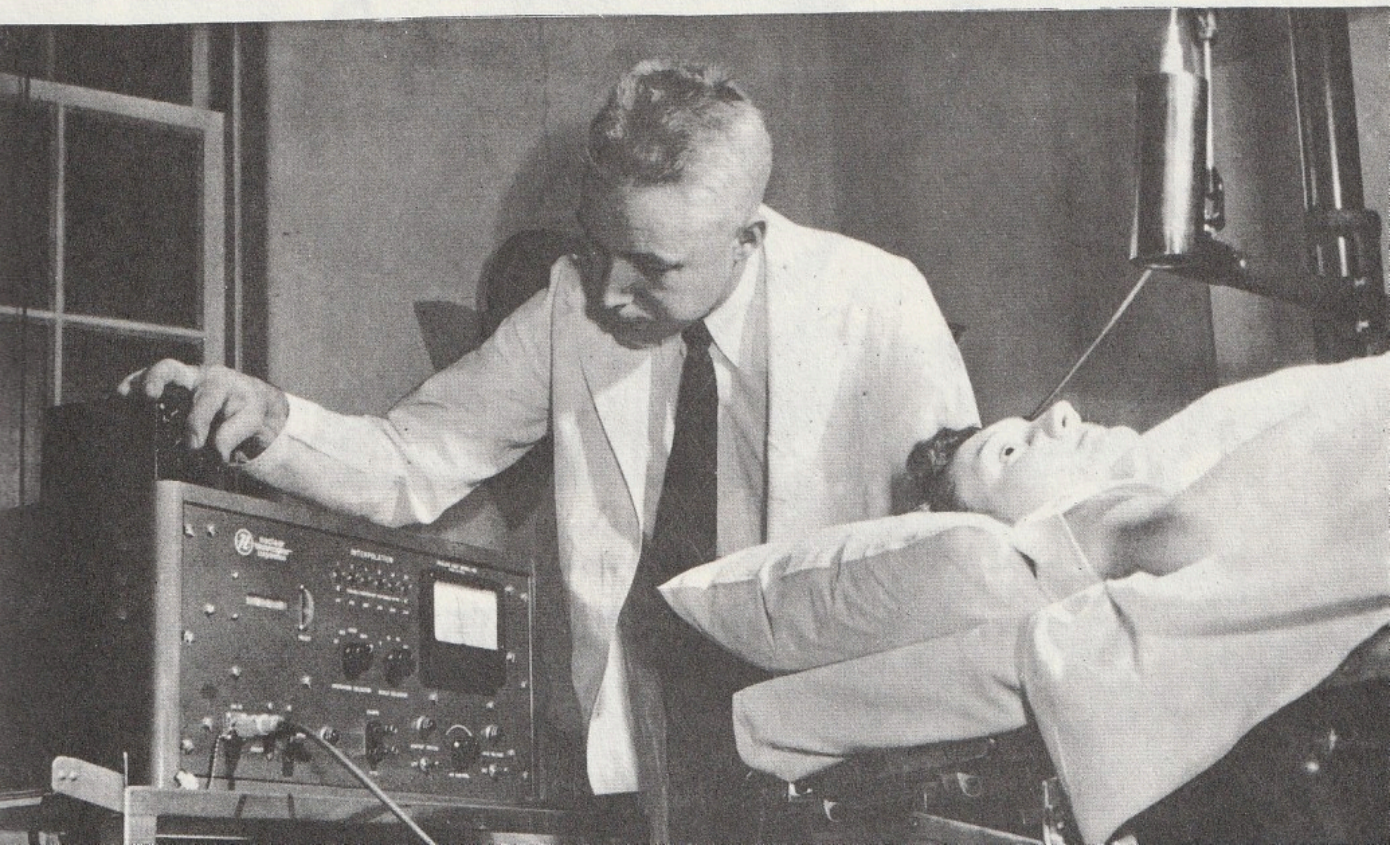
the dishes in which he was culturing a bacterium, *staphylococcus aureus,* the microbe that causes boils. This mold did not belong on the dish; it had simply "fallen" there from the air. Fleming observed that wherever the contaminating mold was growing, the staphylococcus failed to grow. He reasoned correctly that the mold must have been producing a substance that prevented the growth of the bacterium.

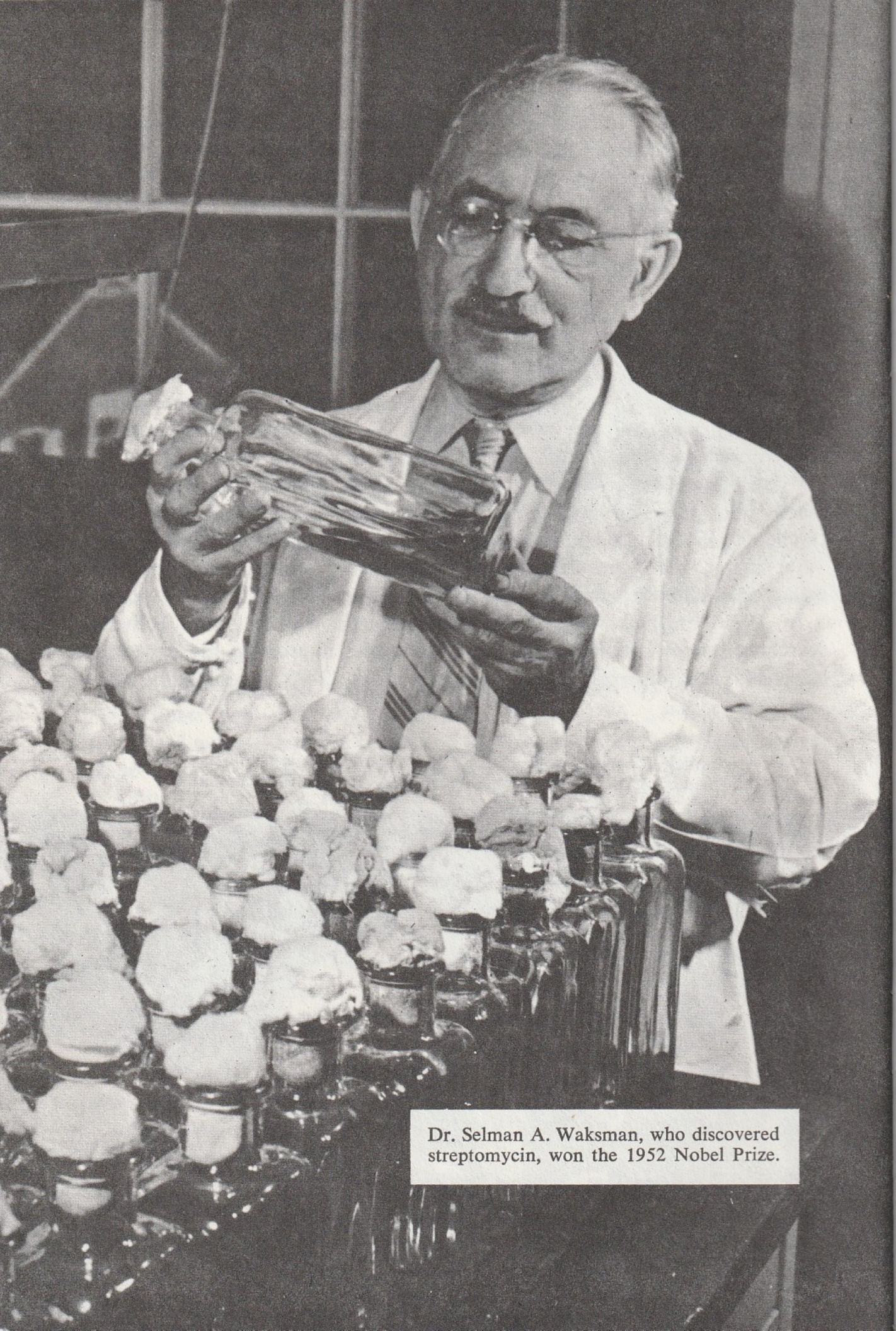
Developing Penicillin

CHECKING FURTHER INTO THIS UNUSUAL MOLD, Fleming found that it was a type called *Penicillium notatum,* and he named the germ-killing chemical produced by it penicillin. Fleming went on to describe the properties of this antibiotic, the disease organisms destroyed by it, and the method of producing it from the mold. Penicillin proved to be much more powerful than pyocyanase and much less toxic. The only problem was the difficulty encountered in extracting it from the mold. After many, many unsuccessful or discouraging efforts, Fleming gave up and penicillin remained a laboratory curiosity for the next ten years.

In 1939 England was at war and research workers were actively searching for an antibiotic that would be useful in treating the expected infections and diseases that accompany wars. Two investigators, Dr.

A scintillation counter, similar to a Geiger counter, is used to measure the amount of radioactivity a patient has received in treatment.





Dr. Selman A. Waksman, who discovered streptomycin, won the 1952 Nobel Prize.

A surgeon, with a scalpel in his left hand, prepares to make an incision in a patient's forearm.

8. USING THE SCALPEL

Howard W. Florey and Dr. Ernest Chain, decided to look further into penicillin. After months of work these men produced enough penicillin to treat a few human infections. They were rewarded with remarkable success.

Since because of the war there was no chance to manufacture enough penicillin in England, Florey and his colleagues decided to bring their antibiotic to the United States and take advantage of mass-production techniques. Through the teamwork of American industry, government

CAUSES OF DEATH AMONG AMERICANS

Rank	Cause of Death	Per Cent of Total Deaths
1	Heart diseases	39.0
2	Cancer	16.8
3	Stroke	10.9
4	Accidents	6.1
5	Flu and pneumonia	3.1
6	Diseases of infancy	2.6
7	Diabetes Mellitus	2.0
8	Arteriosclerosis	1.9
9	Other circulatory diseases	1.6
10	Other bronchial diseases	1.6
11	Cirrhosis of the liver	1.5
12	Suicide	1.2
13	Congenital malformations	0.9
14	Homicide	0.7
15	Other hypertensive diseases	0.6
16	Others	9.5

Source: U.S. Public Health Service

and universities, penicillin was soon being produced in ton quantities and made available to all the world for alleviation of infectious diseases.

Bacteria which cause human disease are classified by trying to dye them with a stain named after Hans Christian Gram, a Danish bacteriologist. Bacteria that can be dyed by the stain are called Gram-positive and include germs that cause boils, pneumonia, scarlet fever and venereal diseases. Penicillin is effective against these diseases—but is useless against the Gram-negative bacteria which cause typhoid, undulant fever and tularemia.

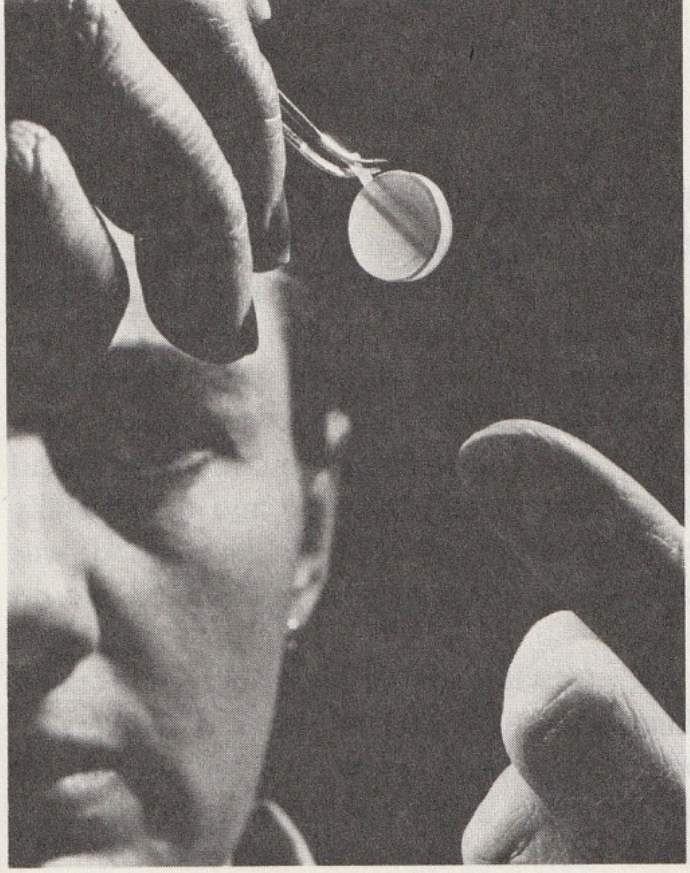
Accordingly there was a gap in the war against infection. Bacteriologists began a search for an antibiotic that would destroy Gram-negative bacteria. It was a Russian-born bacteriologist, Dr. Selman Waksman, working at Rutgers University, who had done much of the original research on antibiotics. In fact, it was he who established the use of the name antibiotics for these potent germ killers.

Streptomycin

In 1944 Dr. Waksman announced the discovery of the antibiotic called streptomycin. He had isolated a soil microbe that produced this antibiotic, effective against Gram-negative bacteria and also against the tuberculosis germ. Shortly, streptomycin was in use. Then, more and more antibiotics came into being. In 1946, chloromycetin; in 1948, aureomycin; and in 1950, terramycin. Each of these antibiotics was effective against Gram-negative and Gram-positive bacteria. They were discovered by drug companies engaged in screening soil samples for microbes capable of producing antibiotics. Fleming, Florey and Chain received the Nobel Prize for penicillin, as did Waksman for streptomycin. Antibiotics had become the single most important contribution to medicine in the first half of the twentieth century.

Uses and Abuses of Antibiotics

Alexander Fleming would probably be amazed today if he could see the tremendous number of uses to which antibiotics have been put. In addition to the widespread use of antibiotics in control of infectious diseases in man, antibiotics are used in treating animal diseases, in controlling bacterial disease of plants, in food preservation and as a feed supplement for poultry, pigs and cows. In each of these



The first living system duplicating human cell reproduction outside of the body was achieved at the Brookhaven National Laboratory in the United States.

uses the antibiotic acts to destroy bacteria that are causing disease, spoiling food or interfering with normal animal growth.

Tons of antibiotics are produced each year and hundreds of millions of dollars' worth of antibiotics are used yearly for the purposes described. With all these advantages provided by antibiotics, one must ask, "Are they ever harmful?" Unfortunately, the answer is yes.

Antibiotics, like any other drugs, are harmful when used unnecessarily or used improperly. Among the harmful reactions that have occurred due to unwise use of antibiotics are: allergic reactions in certain individuals; and nausea, vomiting and other toxic reactions in some persons. In addition, some bacteria have become resistant to the action of some antibiotics and are no longer destroyed by them.

Only a small percentage of the population is affected by harmful reactions, but sometimes the reactions are extremely severe and a danger to health. It is therefore wise to know that antibiotics should never be taken without the strict guidance of a physician.

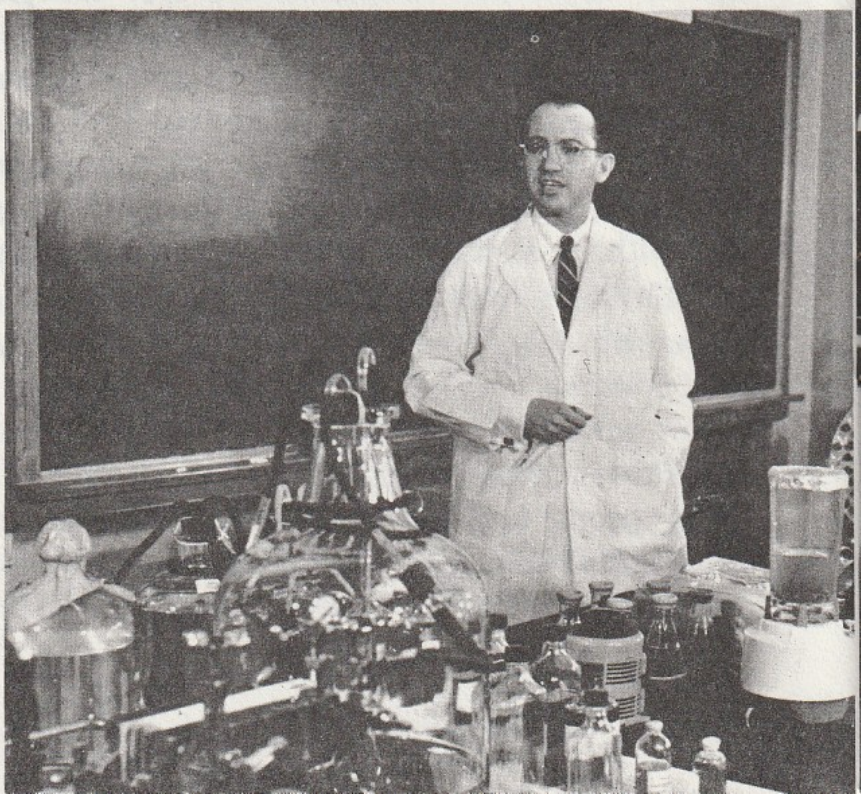
Polio Vaccine

As was true with other great discoveries in medicine, many people had to contribute to the research on polio before a vaccine could be developed to combat it.

Jenner, of course, was the first to demonstrate that vaccination could provide resistance to a given disease—so he must be given some credit. Then a big contribution was made in 1909 by Dr. Karl Landsteiner, who showed that polio could be transmitted from man to monkeys in the laboratory. Landsteiner also showed that the disease was transmitted by a microbe smaller than bacteria—that polio actually was caused by a virus. Another important researcher in polio investigation was Dr. David Bodian, who described polio virus in the throat, intestine and occasionally in the blood of patients. The observation of polio in the blood was important because this is the area where antibodies of an infected person fight off the virus.

The most important of all early studies which contributed to polio vaccine was that of Dr. John Enders and his staff at Harvard University. In 1949 Dr. Enders demonstrated that he could grow polio virus in a test tube by feeding it on monkey tissues. This was quite revolutionary because no satisfactory way to do this was known at the time.

It was then that Dr. Jonas Salk at the University of Pittsburgh Medical School began to develop a vaccine. Salk had observed, with others, that people who had polio developed a resistance to further infections from polio virus once they had recovered from the disease. This was, of course, similar to the observations that Jenner made with cowpox and smallpox. Salk reasoned that if healthy people could be injected with polio virus, they, too, could develop resistance to the disease and be



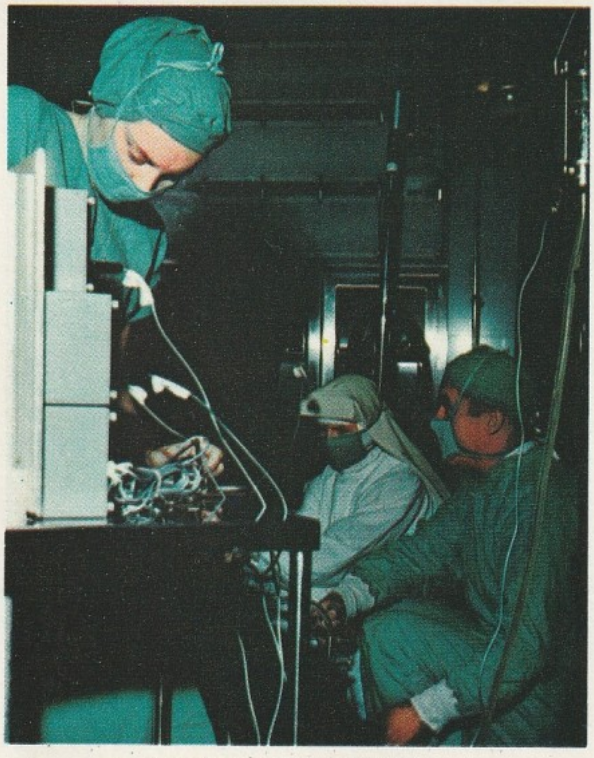
Dr. Jonas E. Salk explains how the red liquid vaccine, which he developed to fight polio, is made.

protected for the future. In 1954 he grew polio virus in large quantity, following the procedure of Dr. Enders. Salk then added a chemical called formalin to the virus, which killed it and made it incapable of causing polio on injection. Purification procedures followed, and the virus was ready as a vaccine. Later an oral vaccine was developed by Dr. Albert B. Sabin of the University of Cincinnati, and approved for use in 1963.

In 1952, before the introduction of the Salk and Sabin vaccines, there were 21,300 cases of paralytic polio in the United States and 1,400 deaths. By contrast, paralytic polio is virtually unheard of in the United States today. Throughout the world, the Salk and Sabin vaccines have been hailed as truly great discoveries of medicine.

Much Remains to Be Done

WHILE MEDICAL DISCOVERIES HAVE HELPED increase man's life span to almost twice what it was a century ago, much remains to be done. Fortunately, current research indicates that rapid progress lies ahead.



Members of a hospital staff operate the heart-lung machine during an operation.

5. THE HEART-LUNG MACHINE

THE FIRST HUMAN HEART TRANSPLANT

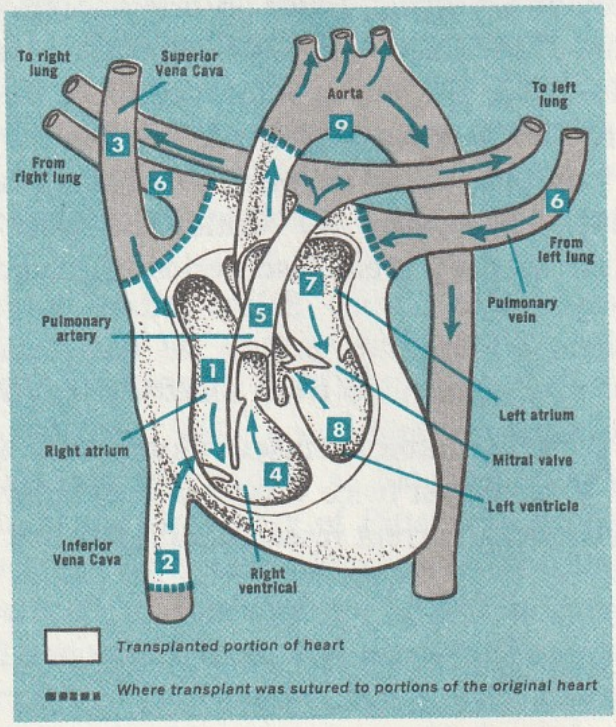
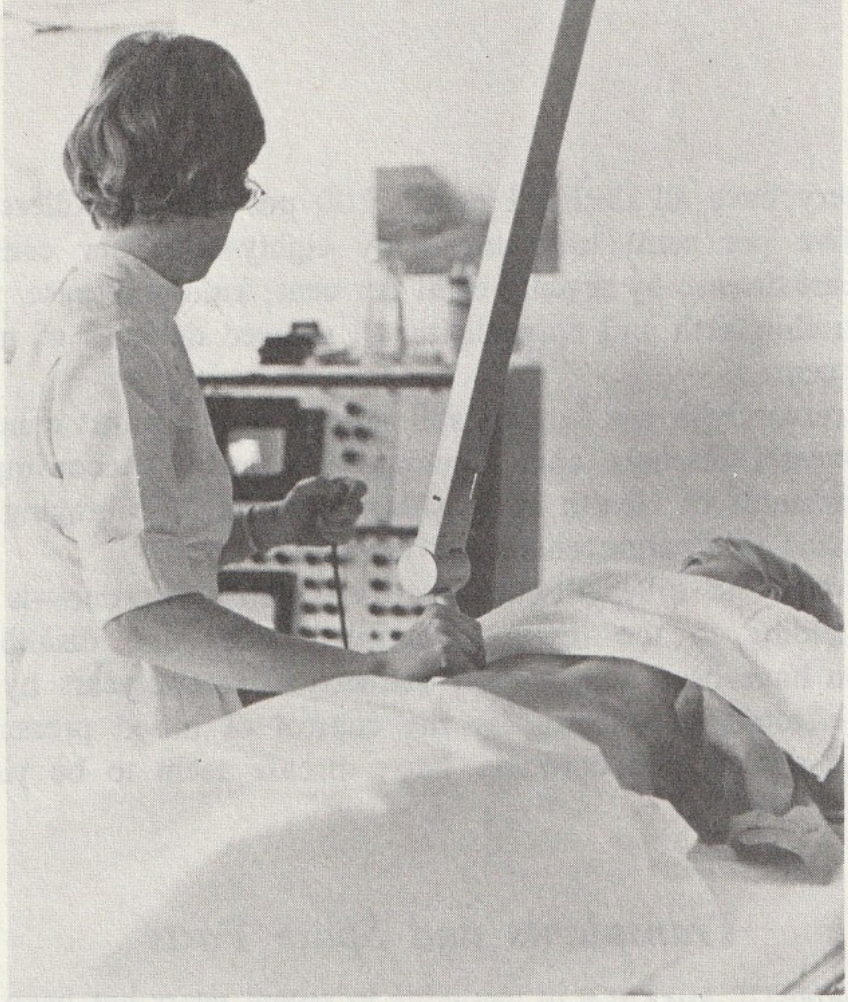


Diagram shows the first heart transplant, performed in South Africa in 1967. The heart of a man was removed completely except for the shaded portions of the right and left walls of the upper chambers, which contain the superior vena cava and the pulmonary veins. These were left intact to keep to a minimum the number of blood vessels that had to be severed. Then the heart of a 25-year-old woman was sutured into place at the excision sites. The composite heart then functioned like a normal heart in which blood returning from the lower half of the body enters the right atrium (1) through the inferior vena cava (2). Blood returning from the upper half of the body enters this atrium through the superior vena cava (3). The blood then enters the right ventricle (4), where it is pumped through the pulmonary artery (5) into the lungs to be oxygenated. The blood returns to the heart through the pulmonary veins (6) and enters the left atrium (7). It then passes into the left ventricle (8), where it is pumped into the aorta (9) for distribution throughout the body.

—Courtesy *The New York Times*

It is now clear that the past two decades have sparked a "medical revolution" that promises even greater activity ahead. This revolution was made possible by vast changes in the methods of research. Instead of scientists working independently and alone—hoping to stumble onto some new discovery, but not really equipped to test or apply their findings—today's medical research uses a team approach. There is, in short, a movement toward adopting twentieth-century industrial concepts throughout the field of medical science. More and more laboratory research is co-ordinated with tests and treatment at the practical level—at the patient's bedside or in a doctor's office.



An ultra-sound unit is among the latest tools to help diagnose a patient's ailment.

In the field of infection, the virus diseases are still a great challenge, but "wonder drugs" have brought striking victories. In the fight against German measles, for example, the first effective vaccine against this deformer and killer of unborn babies was approved by the government in 1969 and by 1974 more than 50 million children in the United States had been vaccinated. In the next few years German measles, like polio, will be a thing of the past. Safe vaccines have been found for use against such common and potentially dangerous diseases as mumps and diphtheria. Tuberculosis can now be treated by drugs, without the lengthy hospitalization once required. Antibiotics—all of them brought into general use after World War II—have drastically reduced deaths from infected wounds. They have also made it possible to conduct delicate surgical operations by further cutting down the danger of infection in operating rooms.

Medical officials reported in 1974 that smallpox had been eradicated from the Western Hemisphere. That calls to attention the decline in deaths from other diseases in just the past twenty years. Polio, whooping cough

and dysentery have all declined nearly 100 per cent as killers; syphilis by ninety-five per cent; tuberculosis by eighty-eight per cent; hypersensitive heart disease by seventy-eight per cent; kidney disease, maternity mortality in childbirth and appendicitis all showed declines of more than seventy per cent.

Medical researchers are fighting still unwon wars against cancer, heart and blood-vessel diseases and rheumatoid arthritis. According to the National Institutes of Health in Washington, D.C., encouraging progress has been made in treating childhood leukemia.

The number one killer disease—cardiovascular disorder—is showing signs of yielding to the research assault. Death and disability from hypertension have been substantially reduced in recent years by a whole battery of effective new drugs for the control of blood pressure. Congenital heart defects and coronary heart disease seem to be yielding to research.

Transplants and Spare Parts

ONE DRAMATIC ADVANCE in medicine in recent years has been in organ transplants—the most spectacular being the transplanting of a heart from one human to another. These operations are still rare because of high mortality rates. Medically, the true value of heart transplants is still being assessed. On the other hand, kidney transplants have become more common, with thousands having been performed since they were first attempted in the 1950s. Liver transplants have been moderately successful, and experiments are being carried forward in transplants of human lungs and pancreas. Corneas (eye) and bone marrow also seem to be transplantable human parts.

Open-heart surgery is another dramatic development. By 1974 almost 100,000 such operations were performed in the United States alone. It is becoming almost a routine procedure for a surgeon to cut into a living heart to replace or repair some ailing part of it.

A companion field to the transplant of natural organs is the use of artificial devices to augment or replace natural organs. Artificial kidney machines have maintained the lives of some patients for years by intermittent treatment. Any of these patients would have died in a month without this help.

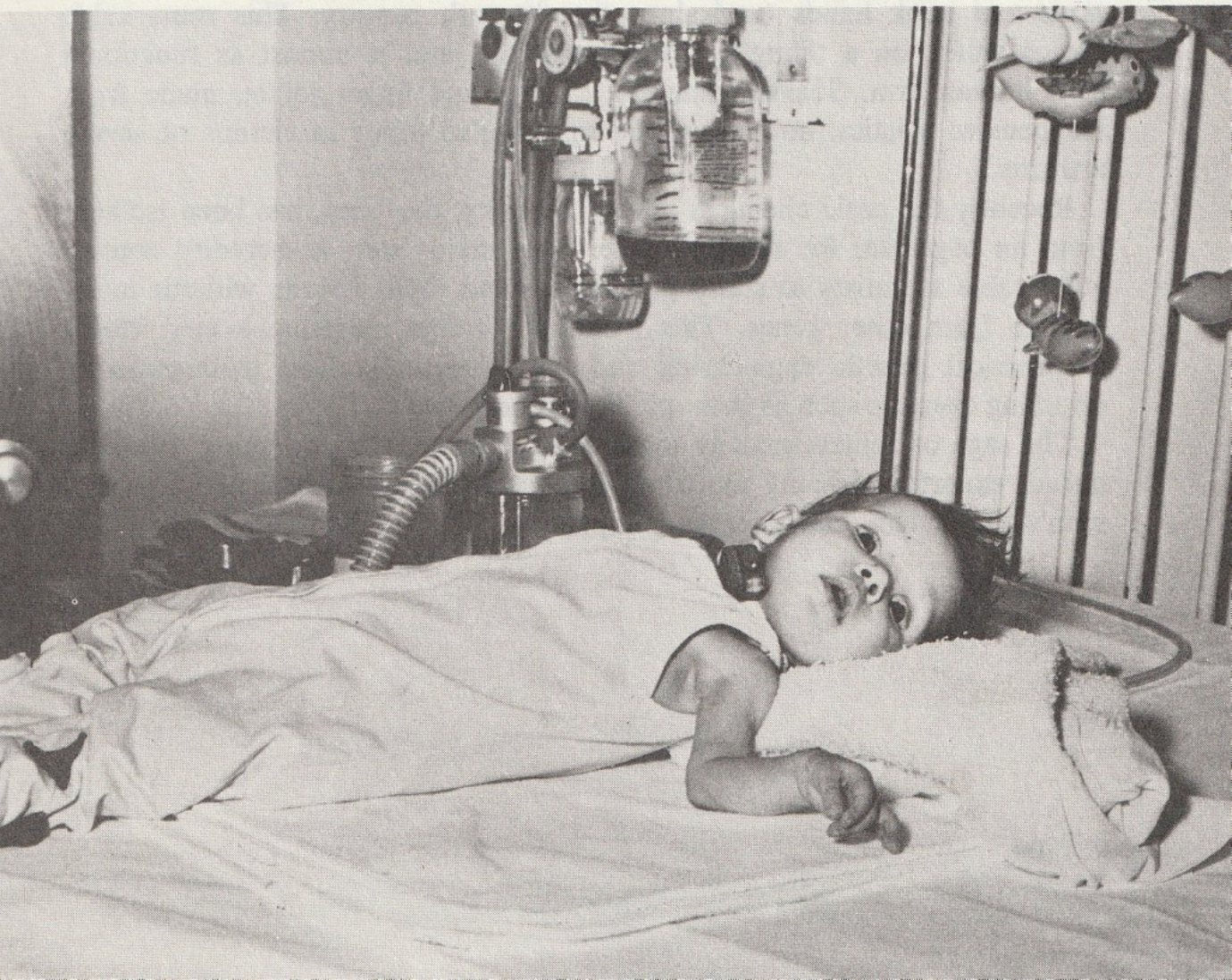
Tens of thousands of people have been given artificial heart valves, others have received segments of vital artery made of dacron mesh, and

still others walk around with battery-powered "pacemakers" imbedded in their bodies. These pacemakers are electrical devices to maintain the rhythm and strength of heartbeats. Today, more than 50,000 Americans wear pacemakers. Nuclear scientists are developing an atomic-powered pacemaker built to last a lifetime, making it unnecessary to open a patient's chest every two or three years to replace the batteries that provide power in conventional pacemakers.

Teflon, a non-stick coating developed for household appliances, has been used for artificial hip and knee joints, as well as for windpipes, corneas, heart valves and bone replacements. And the uses of plastics and other man-made materials in surgery are growing.

The National Heart Institute is sponsoring a research program aimed at developing devices to replace the heart. Ultimately, nuclear-powered blood pumps could replace as many as 200,000 human hearts annually. Many surgeons agree that artificial devices are more realistic answers

From space research comes the tiny sensor and radio transmitter at the neck of this four-month-old girl. They will sound an alarm if she experiences breathing difficulty.



to the challenge of heart replacement than human transplantation. Engineers, working with doctors, are trying to construct new parts of the body all the time. Many speak seriously of artificial liver, stomach, intestine and pancreas, made of plastics or metal.

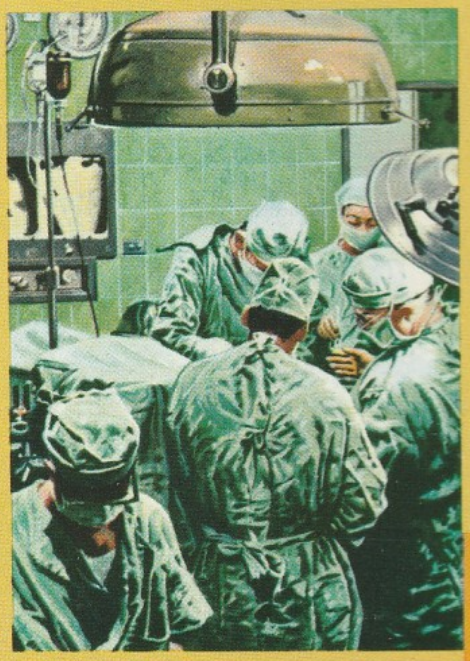
An Almost Endless List

THE LIST OF ADVANCES GOES ON AND ON. Take "nuclear medicine", virtually undeveloped just a few years ago. By using radioactive chemicals injected into the body, doctors can spot and often treat deep-seated illnesses such as cancer in bones, joints and soft tissues that they could not reach before. More than 4,500 hospitals in the United States use nuclear medicine. From the space program have come other amazing spinoffs. Two examples will make the point: One is the use of blood-purifying plastics used as filters in artificial kidneys. Another is a close chemical relative of rocket fuel, called procarbazine, which has proved valuable in treating cancer of the lymph system.

In other fields: The use and development of artificial limbs has been impressive. The so-called Boston arm is a far cry from the rigid wooden arms and hook hands used since the fifteenth century. This remarkable device works on a thought-control principle, and is almost as functional as a human arm. Silastic knuckles, elbows and finger joints, made from inexpensive plastics, now are replacing crippled joints in victims of severe arthritis.

Recently the basic chemical unit of heredity, the gene, has been isolated from an organism for the first time. This major step in heredity control will enable scientists to study pure genes and their actions without interference from other genes. This technique brings medicine a step closer to practical genetic engineering and may eventually lead to conquering crippling diseases such as hemophilia and diabetes.

The saga of achievement is continuous and highly encouraging. Looking ahead, experts see many more medical discoveries—all designed to make man's life longer, healthier and happier.



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